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TSARINA—A Computer Model for Assessing Conventional and Chemical Attacks on Airbases

Donald E. Emerson

September 1990

RAND

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TSARINA—A Computer Model for Assessing Conventional and Chemical Attacks on Airbases

Donald E. Emerson
with Louis H. Wegner

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Prepared for the
United States Air Force

RAND

PREFACE

This Note describes the latest release of RAND's TSARINA (TSAR INputs using AIDA) airbase damage assessment computer model, which was developed for examining chemical as well as conventional air attacks against complex targets. The TSARINA model assesses the chemical deposition and the conventional losses and damage to various categories of resources, including buildings and facilities. This latest version extends the previously available code so that (1) attacks may be designated against the minimum operating surface (MOS) defined after prior attacks, (2) aircraft shelters may be damaged, as well as destroyed, and shelter damage can be greater for hits near the main door, and (3) unexploded ordnance (UXO) can be "timed" to detonate (in the TSAR simulation). Although TSARINA was designed as a special-purpose model for use with the TSAR (Theater Simulation of Airbase Resources) computer model, it may also be employed alone as a general-purpose damage assessment model (however, in this mode features that involve interaction with TSAR naturally are inoperative). The present Note includes detailed user instructions.

TSARINA and TSAR are Monte Carlo models that were developed by RAND for studying alternative means of sustaining and improving wartime sortie generation capabilities at airbases, despite unexpected demands and sudden unpredictable resource shortages imposed by air attacks with conventional and chemical weapons. TSARINA has a variety of possible applications. It can be used separately to assess the losses that would be sustained from a campaign of air attacks on airbases (or other complex targets), and to assess the impact of various dispersal or hardening proposals on the expected losses. It can also be used in conjunction with the TSAR simulation model to assess the impact of chemical casualties and disruption as well as conventional airbase damage on sortie generation capabilities, and to evaluate proposals for improving those capabilities at an airbase or a set of airbases.

The model has been in use in many Air Force agencies for some years, including the Office of the Assistant Chief of Staff for Studies and Analyses and the Air Force Airbase Operability Management Office (AFSC/MSD/YQ), among others. This Note is being published to provide documentation for the use of the latest release of the model and to introduce it to a wider audience. The companion Notes include:

N-3011-AF *TSAR User's Manual—A Program for Assessing the Effects of Conventional and Chemical Attacks on Sortie Generation: Vol. I—Program Features, Logic, and Interactions*

N-3012-AF *TSAR User's Manual—A Program for Assessing the Effects of Conventional and Chemical Attacks on Sortie Generation: Vol. II—Data Input, Program Operation and Redimensioning, and Sample Problem*

N-3013-AF *TSAR User's Manual—A Program for Assessing the Effects of Conventional and Chemical Attacks on Sortie Generation: Vol. III—Variable and Array Definitions and Other Program Aids*

This work was conducted under the Project AIR FORCE Resource Management Program.

SUMMARY

This Note describes the latest version of the TSARINA (TSAR INputs using AIDA) airbase damage assessment computer program that has been developed to estimate the on-base concentration of toxic agents that would be deposited by a chemical attack and to assess losses to various on-base resources from conventional attacks, as well as the physical damage to runways, taxiways, buildings, and other facilities. Although the model may be used as a general-purpose, complex-target damage assessment model, its primary role is intended to be in support of the TSAR (Theater Simulation of Airbase Resources) aircraft sortie generation simulation program. When used with TSAR, multiple trials of a multibase airbase-attack campaign can be assessed with TSARINA, and the impact of those attacks on sortie generation can be derived using the TSAR simulation model.

TSARINA, as currently configured, permits damage assessments of attacks on an airbase (or other) complex that is composed of up to 1000 individual targets (buildings, taxiways, etc.), and 2500 packets of resources. The targets may be grouped into as many as 30 different vulnerability categories, and different types of personnel, equipment, munitions, spare parts, TRAP (tanks, racks, adaptors, and pylons), building materials, and POL (petroleum, oils, and lubricants) can be distinguished. The attacks may involve as many as 100 weapon-delivery passes and 20 types of weapons. Point-impact weapons (such as general-purpose bombs, precision-guided munitions, and boosted kinetic energy penetrators), dispenser weapons (such as cluster bomb units (CBUs) and mine dispensers),[1] and chemical weapons that can be delivered by aircraft or missiles can be modeled.

TSARINA determines the actual impact points (pattern centroids for CBUs and container burst point for chemical weapons) by Monte Carlo procedures—i.e., by random selections from the appropriate error distributions. Uncertainties in wind velocity and heading are also considered for chemical weapons. Point-impact weapons that impact within a specified distance of each target type are classed as hits, and estimates of the damage to the structures and to the various classes of support resources

[1]Weapons that combine point-impact munitions, and CBUs or mines (such as the JP-233 and DAACM), may also be modeled.

are assessed using "cookie-cutter" weapon-effects approximations. This latest version of TSARINA permits target height to be taken into account for point-impact weapons that impact with a nonvertical trajectory. In addition to the weapon-effects procedures used with RAND's Airbase Damage Assessment (AIDA) computer model, this model also permits use of a novel two-level cookie-cutter representation for assessing damage to the various classes of resources. For dispenser weapons, damage to targets and resources is based on a specified damage expectation for targets within the rectangular area of effects of each dispenser.

For each trial computation of an attack, the program determines the fraction of each target covered by the circular damage coverage patterns of point-impact weapons, the damage expected from dispenser weapons, and the local concentration of chemical agents. The results include estimates of the overall damage to each target and to all resource classes collocated with that target. When mines are dispensed or unexploded ordnance is simulated, their numbers are recorded for each taxiway/runway segment, and the effects of the subsequent detonation of the unexploded ordnance (UXO) can be assessed in TSAR. In addition, the output includes an estimate of the damage sustained by each type of resource at its various storage locations. The attack may be repeated automatically for several trials to provide statistics on the average damage levels to each of the targets and to each type of resource.

The targets that are designated as runways or taxiways suitable for aircraft operations are examined to see if an area of a user-specified size is available for aircraft operations; if not, the minimum number of craters that would need to be repaired to obtain an area of that size is determined. The "minimum-operating surface" may be constrained to be parallel to the sides of these targets or it may be skewed.

The TSARINA program was originally written in FORTRAN IV, and has been updated to FORTRAN 77; it has been adapted to various computer systems, as was the widely used AIDA model and the previous versions of TSARINA. This Note provides a full discussion of the use of TSARINA as a general-purpose damage assessment model and outlines in detail the special requirements for its use in conjunction with the TSAR simulation program. Most features of the model are illustrated with a sample problem. Appendixes include a description of TSARINA input requirements and definitions of all variables and arrays found in TSARINA common statements.

ACKNOWLEDGMENTS

I particularly wish to acknowledge Dr. Louis Wegner of RAND, co-author of the 1985 set of TSAR/TSARINA manuals, for his important contributions to these models in the early 1980s. Dr. Wegner's contributions include (1) the data structure for runway and taxiway damage, (2) the efficient algorithms for runway and taxiway repair, (3) the elegant, compact representation of deposition, evaporation, and vapor transport of chemical agents, and (4) the modeling of chemical casualties. Dr. Wegner also wrote Sec. V in the 1985 TSARINA manual and portions of Sec. IX of the 1985 TSAR manual; these sections remain essentially unchanged in the current versions.

These latest TSAR/TSARINA user's manuals, and the latest model software, have benefited from many helpful suggestions offered over the years by TSAR/TSARINA users. Their help has ranged from ideas for clarifying the documentation, to pinpointing obscure coding errors. And several were ideas for additional capabilities, many of which are reflected in the new features made available in these latest versions. I wish especially to note the suggestions of RAND colleagues John Folkeson and Michael Kennedy, the personnel at Orlando Technology (notably the late Dale Robinson), Ted Hayes (while at JAYCOR), Larry George of the Lawrence Livermore Laboratory, and Captains David Deiner and Robert O'Neill of the Air Force's Center for Studies and Analysis; all have helped to make possible a more effective product.

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GLOSSARY

AGE	Aerospace Ground Equipment and other support equipment used for carrying out various tasks
AIDA	AIrbase Damage Assessment model; the forerunner of TSARINA
AIS	Avionics Intermediate Shops; special test equipment used for repairing avionic LRUs and SRUs
AMU	Aircraft Maintenance Unit; the organization providing maintenance for an aircraft squadron
ATC	Air Traffic Control
BKEP	Boosted Kinetic Energy Penetrator
BLSS	Base-Level Self-Sufficiency stock of aircraft spare parts; composed of the stocks for peacetime, plus additional material to meet wartime demands
CAP	Combat Air Patrol
CAS	Close Air Support
CBU	Cluster Bomb Unit
CCD	Camouflage, Concealment, and Deception
CEP	Circular Error Probable
CILC	Centralized Intermediate Logistics Concept
CIRF	Centralized Intermediate Repair Facility
COB	Collocated Operating Base
COMO	Combat-Oriented Maintenance Organization
CONUS	Continental United States
CRS	Component Repair Squadron; a wing-level organization responsible for parts repair
CW	Chemical Warfare
DAACM	Direct Airfield Attack Cluster Munition
D-DISP	Standard deviation of dispersion in deflection
DEP	Deflection Error Probable
DMPI	Desired Mean Point of Impact
EMD	Effective Miss Distance
EMS	Equipment Maintenance Squadron; a wing-level organization responsible for equipment maintenance and repair

EOD	Explosive Ordnance Disposal
FRAG	FRAGmentary order that specifies flight requirements
GB	The chemical agent Sarin
GD	The chemical agent Soman
GP	General-Purpose bomb
GPS	Global Positioning System
HD	Distilled mustard gas
IAM	Inertially Aided Munition
ILM	Intermediate Logistics Maintenance; on-base parts repair supporting the AMU
IPE	Individual Protection Equipment for a chemical environment
JMEM	Joint Munitions Effectiveness Manual
LCOM	Logistics Composite Model
LRU	Line Replaceable Unit; an aircraft spare part with distinguishable subordinate components
MAE	Mean Area of Effectiveness
MCL	Mean Clear Length of MOS
MCW	Mean Clear Width of MOS
MMD	Mass Median Diameter of chemical droplets
MOB	Main Operating Base
MOPP	Mission Oriented Protective Posture (the CW ensemble)
MOS	Minimum Operating Surface
MP	Monitoring Point
NMCS	Not Mission Capable because of lack of Spare parts
NORS	Not Operationally Ready because of lack of Spare parts; same as NMCS
NRTS	Not Reparable This Station
OST	Order and Ship Time in days; time for a NRTSed or condemned part to be replaced
PAA	Program Authorization, Aircraft
PGM	Precision-Guided Munition
POL	Petroleum, Oils, and Lubricants; often used as an abbreviation for aircraft fuel
POS	Peacetime Operating Stock; an organization's stock of aircraft spare parts for aircraft maintenance in peacetime

RAM	Rapid Area Maintenance; special mobile teams used for repairing aircraft battle damage
R-DISP	Standard deviation of dispersion in range
REP	Range Error Probable
Resource class	All airbase support resources are grouped into seven classes: personnel, equipment and AGE, aircraft spare parts, munitions, TRAP, building materials, and POL.
Resource type	Different types of resources may be distinguished within each resource class; e.g., different types of aircraft maintenance specialists.
Resource packet	A user-specified percentage of a given resource type that is located at a specified target
RR	Flight line maintenance that removes and replaces malfunctioning aircraft parts with serviceable components; generally implies no local repair
RRR	Flight line maintenance that removes, repairs, and replaces aircraft spare parts (actually, usually removes and replaces with a serviceable unit, and then repairs the malfunctioning unit)
RRR	Rapid Runway Repair
SAMSOM	Support Availability Multi-System Operations Model
SCL	Standard Combat Load that designates the aircraft configuration and the mission dependent munitions to be loaded
SE	Support Equipment; usually referred to as AGE in TSAR
SF	Spread Factor
SRU	Shop Replaceable Unit; a component of an LRU
Target	A target is represented by a rectangle that is located in an X-Y coordinate system; individual buildings, runways, taxiways, parking areas, etc., can be designated as targets.
Target complex	A target complex, such as an airfield or an industrial area, is a collection of rectangular targets
Target type	A target type is specified for each target; all targets of the same type have the same vulnerability, and all resource types of the same resource class located at the same type of target have the same vulnerability

TBM	Tactical Ballistic Missile
TLE	Target Location Error
TRAP	Tanks, Racks, Adaptors, and Pylons
TSAR	Theater Simulation of Airbase Resources
TSARINA	TSAR INputs using AIDA
UXO	Unexploded Ordnance
VX	A chemical agent
WRM	War Reserve Materiel
WRSK	Wartime Readiness Spares Kit

I. INTRODUCTION

TSARINA[1] (TSAR INputs using AIDA) is the latest version of an adaptation of the AIDA (AIrbase Damage Assessment) computer model[1]; this version has been developed to simulate airbase attacks with chemical weapons and to generate more detailed damage data for conventional attacks. Both TSARINA and TSAR are Monte Carlo models. TSARINA permits assessments to be developed for a campaign of air attacks and prepares those assessments for entry into the TSAR (Theater Simulation of Airbase Resources) sortie generation model [9–11], which can assess the impact of the destructive and disruptive effects of conventional and chemical attacks on sortie generation.

In the first version of TSARINA [12], several key additions were made to the AIDA model so that (1) the on-base location of resources (e.g., personnel, munitions, and aircraft spare parts) can be readily associated with various targets (structures/facilities), (2) different MAEs (mean areas of effectiveness) or PKs (kill probabilities) can be defined for the different resources, and (3) a novel two-level "cookie cutter" can be used to represent the effectiveness of weapons against the various classes of resources. In addition, the various effectiveness values may be different for direct hits and for near misses. With these added input data, TSARINA generates estimates of the losses among the various on-base resources, in addition to the estimates of hits and facility damage that are generated by the original AIDA model. The second version of TSARINA [13] was further modified to permit the effects of chemical weapons to be examined and to permit runway-taxiway clearance and access problems to be treated in substantially greater detail than in the initial version. The current version permits the user to target the minimum operating surface (MOS) selected after prior attacks, to damage (as well as destroy) aircraft shelters, and to select a skewed MOS; it also provides a variety of additional features.

[1]Various analysts in the community continue to use earlier releases of TSARINA or TSAR [2–8] and refer to them by various "names," such as TSARINA-III or TSAR-II, etc. The version supported by this document will be referred to simply as TSARINA and is the version available as of mid-1989. The versions distributed in 1980 [12] and 1985 [13] will be collectively referred to as Early-TSARINA; they are no longer supported by RAND.

TSARINA may be used either as a special-purpose model in support of the TSAR simulation, or, with some limitations, as a general-purpose damage assessment model. When used with TSAR, multiple trials of a multibase airbase-attack campaign can be evaluated with TSARINA, and the impact of those attacks on sortie generation can then be evaluated using TSAR. When TSARINA is used for damage estimates only, the various protocols required for use with TSAR (Sec. III) may be ignored.

Using TSARINA, the user is able to specify the size, location, and nature of several hundred rectangular targets and the characteristics of up to 100 weapon-delivery passes.[2] Targets can be categorized into 30 vulnerability classes, and up to 20 types of weapons may be employed; point-impact munitions, dispenser munitions, and chemical weapons may be combined in each attack.

[2]The maximum numbers of targets, munitions, and weapon-delivery passes are readily changed, by redimensioning data arrays.

II. TARGET DATA

In AIDA and TSARINA, the facilities on an airbase are represented as a target complex consisting of a number of rectangular targets (e.g., aircraft shelters, runways, parking ramps, and buildings); the size, location,[1] and type of each target are specified. With TSARINA, the user can estimate the damage to aircraft in shelters, on parking ramps, and on taxiways, and may also estimate the losses to those support resources that are associated with each target. The support resources that can be identified with targets may be grouped into seven classes: (1) personnel, (2) equipment, (3) aircraft spare parts, (4) munitions, (5) tanks, racks, adaptors, and pylons (TRAP), (6) building materials, and (7) petroleum, oils, and lubricants (POL). And within each class, different subclasses may be distinguished by type; for example, pilots, crew chiefs, radar repair specialists, and weapons loaders could be distinguished as different types of personnel. Hereafter, the term *resource* will refer to a particular resource class and type.

The user may specify the percentage of each support resource (a resource packet) that is located at each facility. Thus, personnel with different specialties may be located at different facilities; aerospace ground equipment (AGE) and other equipment can be located in various buildings or parked in designated areas; and different types of munitions, TRAP, etc., can similarly be located in various proportions at various on-base facilities.

The losses from conventional attacks that are estimated for each resource depend upon the attack weapon type, weapon impact locations, resource class, and target type, location, and orientation.[2] Expected aircraft damage and kill probabilities are determined for each aircraft shelter and each parking ramp, and an average value for all taxiways is

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[1]AIDA's restrictions on target location have been relaxed for TSARINA. It is no longer necessary that all targets be located in the first quadrant of the X-Y coordinate system, and the targets may cover an area as large as 32000×32000 dimension units. When the target location entries are not entirely within the first quadrant, TSARINA automatically translates the coordinate system to place all targets (and attacks) in the first quadrant for processing. Furthermore, an auxiliary program is available that will convert dimensional information structured for the Eglin AFB MASSIVE computer program into the format required for TSARINA.

[2]All types of a given resource class, located at targets of the same type, are assumed to have the same vulnerability.

determined for assessing damage to aircraft that are taxiing at the time of the attack. For the support resources, it is assumed that they are distributed within the target with which they are associated, and that the aggregate losses for each resource type are the sum of the losses at each of the targets. Extensive weapon effectiveness data must be supplied for damage calculations to these extended target/resource descriptors, and the user is given considerable flexibility as to how these effectiveness data are expressed, as will be discussed in Sec. IV.

Any number of resource packets may be associated with each target, except that there may be no more than a total of 2500[3] packets. The designations used to specify the different classes of resources are defined in the discussion of supplementary TGT cards in App. A. The "integer" designators that are to be assigned as "names" to the different types of resources are selected by the user; the only constraint is that the maximum integer chosen must not be greater than the size of the corresponding storage array.

TSARINA's treatment of runways is an extension of that for AIDA. Runways must always be identified as Type #1 targets; up to MXRWY runways may be specified at an airbase. When the minimum clear length (MCL) and width (MCW) needed for flight operations are identified, and the "minimum repair requirements" option is requested (on the CONT card), all runway targets are searched to find whether or not an uncratered area of the required size exists, and if not, what the smallest number of crater repairs would be to attain that amount of clear space. The locations that are checked may be constrained to be parallel to the sides of the flight surface, or they may be skewed (see the SKEW card). A maximum of 1000 craters may be stored for each runway.

In addition to selecting an MOS, TSARINA may also be directed to check for the availability of up to three shorter surface lengths, which might be applicable for takeoff only, or for lightly loaded aircraft, etc. The TSARINA results for each attack include the multitrial statistics of the number of crater repairs required for each of the surface lengths, but these results are not transferred to TSAR. Rather, the actual craters are used in TSAR so that both the craters of the current attack and those left unrepaired from previous attacks can be taken into account in selecting the MOS. When used with TSAR, certain attacks specified in TSARINA will be handled such that they are assumed to be directed at the MOS selected in TSAR after the preceding attack. Another feature

[3]This restraint is easily changed by redefining MXITEM in the appropriate PARAMETER statement.

in TSARINA permits the user to simulate the use of a "portable" arresting barrier on the runway to decrease the length required for the MOS (see the BAR card in App. A for a discussion of this feature and a description of the inputs required for implementation).

In TSAR, the taxiway system (including the runways) is treated as a network that provides access between the MOS and the aircraft shelters. Each taxiway/runway segment of this network is entered as a target into the TSARINA data base, and the amount of chemical contamination, and the numbers of unexploded ordnance (UXO), mines, and obstructing craters for each segment are computed and transferred to TSAR for use in assessing which shelters and aircraft parking ramps can access the runway and what casualties are expected for personnel and equipment involved in repairs to the network at the time of an attack, or subsequently due to detonation of UXOs. In assessing which bomb craters will inhibit aircraft transit of the taxiways, each crater is examined independently.

For chemical attacks, TSARINA estimates the initial level of surface contamination at each target and the surface contamination and vapor concentration at up to 150 user-specified monitoring points. As many as three different types of agent may be delivered with any of the 20 weapon types[4] during a campaign of attacks. Unlike conventional weapons, no assessment of the effect of chemical weapons is accomplished within TSARINA; rather, the initial contamination levels at the targets, as well as future projections of the residual surface deposition and vapor concentration at each of the monitoring points, are transmitted to TSAR, where casualties are computed and the impact on sortie generation is assessed.

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[4]This restraint may be changed by redefining MXWPN in the appropriate Parameter statement.

III. ASSESSMENTS FOR TSAR

When TSARINA is to be used to generate assessments for the TSAR simulation, it is necessary to make the specifications for the targets and the resources consistent with the conventions used in TSAR. If TSARINA is not to be used with TSAR, but as a general-purpose damage assessment model, the reader may skip to Sec. IV.

The TSAR computer model is a large, complex, task-oriented, event-simulation model that has been developed to estimate the number of effective sorties that can be generated in wartime at a set of airbases with the resources that are available. It has been designed to provide a means of assessing the potential contributions of various initiatives for improving and sustaining sortie capabilities, despite unexpected wartime demands and sudden unpredictable resource shortages imposed by airbase attacks.

When used with TSAR, TSARINA generates the following estimates of the effects of airbase attacks:

- An estimate of the conventional damage to all specified facilities, and to the personnel, equipment, and spare parts that might be present in those facilities.
- Estimates of the conventional damage to each aircraft shelter, and to the aircraft, personnel, equipment, and spares that may be in the shelter during the attack.
- Estimates of the fractional damage inflicted by conventional weapons on whichever types of personnel, equipment, spares, munitions, TRAP, building materials, and POL have had their locations specified in the TSARINA data base.
- The expected percentage loss to any fuel trucks that are being refilled at specified truck refueling facilities at the time of an attack.
- The numbers of UXO, mines, and craters that prohibit aircraft passage on each segment of the taxiway network.
- Detonation delay times for UXO and damage estimates for explosive ordnance disposal (EOD) and civil engineering activities at or near the detonation.

- The locations of all craters on each runway and, by virtue of the data noted immediately above, the numbers of UXO and mines on each segment of the taxiway network that comprises each runway.
- The location of all craters, relative to the center of the MOS, created by attack weapons designated as aimed at the MOS that was determined after the prior attack.
- The time of arrival and the intensity of the initial surface deposition for each of up to three types of chemical agents, and the initial vapor concentration resulting from that disposition, at each designated facility, each aircraft shelter, each aircraft parking ramp, each monitoring point, and each taxiway segment that has sustained conventional damage on any prior attack.
- The number of the monitoring point that is closest to each facility, each aircraft shelter, each taxiway arc, and each parking ramp.
- A record of functions that are housed in the same facility.
- The percentage of each personnel type represented in the TSARINA data base that is associated with each TSARINA target type and with each monitoring point.
- A projection of the future surface and vapor intensities for each chemical agent at each monitoring point.

To compute these outputs, TSARINA needs a substantial data base that defines the airbases, the location of resources on the airbases, and the characteristics of the attacks. The several special data formats used to enter these data into TSARINA are described at length in App. A. However, before these input data can be prepared, the user must understand how an airbase is represented in the TSAR simulation, and how TSARINA model results interface with TSAR. The following subsections explain the relationships.

REPRESENTATION OF AN AIRBASE IN TSAR

An airbase is represented in considerably more detail in TSAR than in the Early-TSAR formulation. Although neither version of TSAR incorporates airbase geometry explicitly, TSAR captures many of the location-dependent effects. And the interdependence of TSAR with TSARINA is substantially greater than with the earlier versions.

Runways, Taxiways, Ramps, and Aircraft Shelters

A primary difference is that an airbase's network of runways, taxiways, parking ramps, and aircraft shelters is treated explicitly in TSAR, and damage data are transferred from TSARINA to TSAR for each of these entities. Following an attack, TSAR uses these data to select the best area on the runways for repairs to obtain an MOS for flight operations, taking into account all craters in each potential operating surface that have not already been repaired. And with the taxiway damage data, TSAR assesses which shelters and ramps can access the MOS, and which will require taxiway repairs before aircraft in the shelter can be launched or recovering aircraft can use the shelter. In addition, TSAR analyzes the taxiway network damage pattern to assign priorities to the taxiway repair work so that it will maximize the rate at which shelters are given access to the MOS [14]. Furthermore, if an attack occurs during repair of a section of the runway or a taxiway, TSARINA transfers an estimate of the expected loss rates for personnel and equipment on each section of the runways and taxiways (and the expected loss rates for personnel, equipment, and aircraft on each aircraft parking ramp).

To minimize the amount of data that must be stored, and to simplify the input requirements for TSAR, the taxiway segments, the aircraft parking ramps, and the aircraft shelters must be numbered identically in both TSAR and TSARINA.

To simplify creation of the needed input data for TSARINA and TSAR, and to minimize the possibility of errors, a detailed sketch should be drawn for each airbase, similar to that shown in Fig. 1. The taxiway network must be represented by a set of taxiways segments, each of which is input as a target. When the taxiway network is defined, a sequence of taxiway segments should be chosen that is coincident with each runway as illustrated in Fig. 1; the target card for each of these segments should specify the actual runway width. After an attack and after an MOS has been selected, all portions of the runways not included as a part of the MOS, and all taxiways, jointly form the taxiway network. The taxiway arcs, aircraft shelters, and aircraft parking ramps should be numbered consecutively and a TSARINA target card should be prepared for each: arc #1 should be the first taxiway segment in the data base; shelter #1, the first shelter; and ramp #1, the first parking ramp. The nodes should then be numbered (consecutively); each taxiway intersection and the end of each taxiway stub should be assigned a unique node number, starting with #1, but otherwise the designation of node numbers is arbitrary. The numbering of the nodes and arcs is illustrated in Fig. 1.

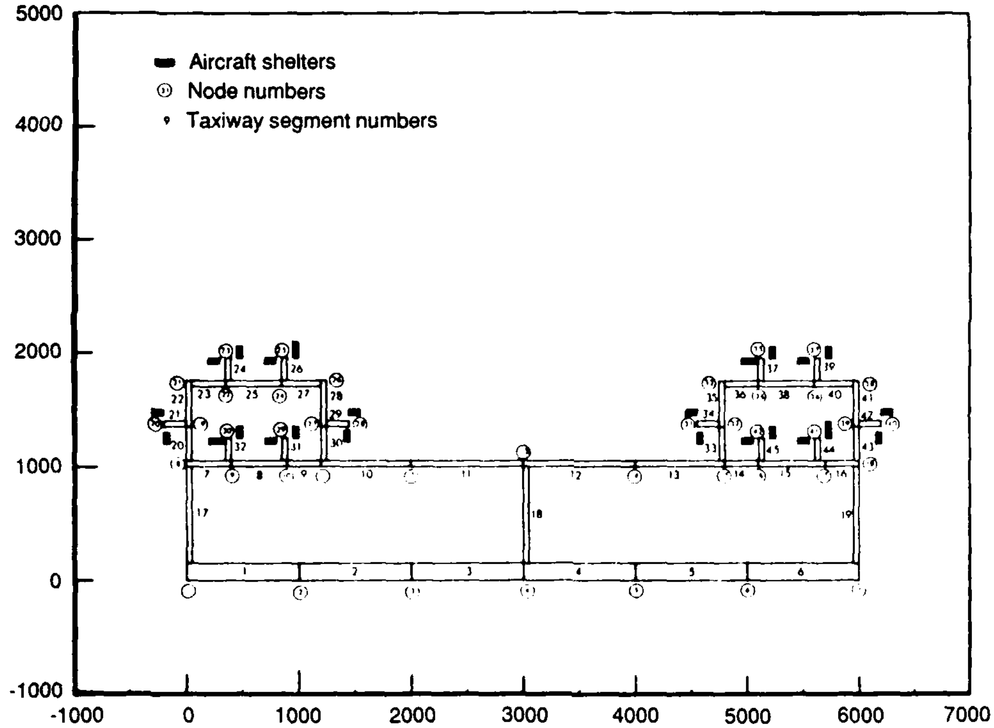

Fig. 1—Layout of runways and taxiway network

Furthermore, the target card for those arcs that constitute the runways, must have a special notation (in column 54) as explained in App. A.

The arc-node relationships are specified in the TSAR input so that model can correctly interpret the taxiway network. The on-base layout of these target elements is specified to TSAR by entering data that define (1) the number assigned to the node at each end of each arc, and the arc length, (2) the number of the node that each aircraft shelter and parking ramp is nearest to, (3) the numbers of the arcs that jointly constitute each runway, and (4) the relative parking capacity of each ramp.

If the effects of chemical attacks are to be evaluated, a set of monitoring points must also be specified in the TSARINA input data. In selecting their locations, it should be remembered that the ambient conditions at a monitoring point will serve as the ambient conditions for all targets closest to that monitoring point, for the TSAR assessments of the persistent effects of chemicals between attacks. Clearly, the monitoring points should be selected near those on-base locations of importance to the evaluation; a uniform grid will generally be inappropriate and wasteful of the substantial processing required in TSAR to update the chemical conditions at each monitoring point.

At the beginning of a TSAR simulation, each aircraft will be assigned a shelter, if sufficient shelters are available. This assignment takes into account (1) the number of user-designated "alert" shelters, for which "alert" aircraft are given priority, (2) the average number of aircraft permitted per shelter, and (3) whatever types of aircraft the user has designated as not able (or not to be permitted) to occupy a shelter. The target cards that prescribe the aircraft shelters designated for "alert" aircraft should be the first shelter target cards entered in the TSARINA data base. Since the shelter number associated with each shelter by TSARINA is based on the order in which the location data are entered, the "alert" shelters are the lowest numbered shelters on the airbase. The user may designate up to three types of aircraft shelters on each base, each with a unique size and physical vulnerability.

In TSAR, aircraft that cannot be assigned to shelters are assigned to parking ramps, considering the relative capacity specified for each ramp. And when aircraft are launched and vacate a shelter, unsheltered aircraft are moved into the empty shelters if they are not a prohibited type. When aircraft recover, they are again assigned to a shelter or parking ramp; if they are to "hot pit" refuel, they first taxi to the specified taxiway segment where the hydrants are located.

With the data transferred from TSARINA that define the personnel, equipment, and aircraft loss percentages for each taxiway segment and each parking ramp, and with the on-base locations of aircraft (and civil engineering runway/taxiway repair activities), TSAR calculates the losses to aircraft, personnel, and equipment at these several locations. In addition, TSARINA averages the damage and kill rates for aircraft on all of the taxiways and transfers those values to TSAR for use with aircraft that are taxiing to or from the runway at the time of an attack. Aircraft caught in the open that are not damaged are returned to a shelter, if one is available. TSARINA also determines the numbers of mines, UXO, and craters on each taxiway segment and the location of all craters on the runways and transfers these data to TSAR. After the attack, TSAR reviews the various data damage generated by TSARINA to select the preferred location for an MOS, taking into account the time and resources that will be required for the necessary repairs. It is presumed that UXO must be removed from a taxiway segment before the mines can be taken care of, and that the mines must be removed before the craters can be repaired. For the simulation of these activities to be realistic, the areas to be cleared of one type of munition before work on the next type can be commenced should be relatively small; otherwise it would be implied that the subsequent activities would wait until the former had been completed over an unrealistically large area. To do this, the taxiway segments that are drawn coincident with the runways should not be over 1000 ft long, thereby permitting work to proceed simultaneously on several different components of an MOS.

Sheltered Aircraft

As noted in Sec. IV, the weapon effectiveness data to be entered into TSARINA for sheltered aircraft are somewhat different from those for other target types. In addition to the effectiveness data against the shelters and the personnel, equipment, ammo, etc., that are in the shelters (up to three distinct types), the effectiveness data also must include the expected damage and kill rates of aircraft in shelters—when the shelter doors are closed and when they are open. A special option permits the simulation to capture the greater vulnerability of the shelter and its contents for bursts in front of the shelter door.

For each attack, TSARINA combines the effects of all the weapons and generates estimates of the probability that an aircraft would be damaged, and the probability that an aircraft would be killed (irreparably damaged), for each shelter. A random number then is drawn for each shelter and a coded number is transferred to TSAR for each shelter where there is any damage; its value specifies that an aircraft would be damaged or killed, both for closed doors and open doors. The estimated damage to the shelter and the loss rates for personnel, equipment, and parts with closed and open[1] doors also are transferred to TSAR.

In TSAR, each aircraft is checked at attack time; if it has been assigned to a specific shelter, the nature of the ongoing maintenance is used to determine if the shelter door is closed or open, and the damage to the aircraft then is based on the coded estimate transferred by TSARINA for that shelter.

[1]When the PAD option is used, survival rates for personnel, equipment, and parts in shelters with an open door are estimated as the product of their survival when the door is closed and their survival due to hits on the pad; when the PAD option is not used, TSAR assumes that the loss rates for these resources when doors are open are in the same proportion as the aircraft damage rates with open and closed doors.

Locations of Other Activities and Resources

The on-base locations of the other sortie generation activities, and of the supporting resources, are important in determining damage at the time of an attack, and, when chemical protective ensembles are worn, in defining the working environment for the activities. For most resources, there is only one way that their locations can be specified—by describing the percentage of each type of resource that is associated with each target in the TSARINA data base.

When the locations of various percentages of particular types of resources are specified in TSARINA, TSARINA assesses the total fraction of those types of resources that have been lost to conventional effects in an air attack and transfers that information to TSAR, where that percentage is applied to the then-existing stocks of those types of resources. This procedure for locating resources is the only option available for assessing losses to munitions, TRAP, serviceable spare parts, building materials, and POL. Since each type of resource (e.g., Mk-82 bombs, AM-2 matting, racks) may be distributed in several locations, each with its distinct vulnerabilities, the vulnerability of these resources can be represented rather realistically (assembled munitions can even be distinguished from the components from which they are assembled).

Personnel and equipment locations at the time of an air attack can also be specified in the TSARINA data base. But for these resources that move about an airbase to accomplish various tasks, the user has the option of letting TSAR determine where these resources are located at the time of an attack and having TSAR determine the damage to these resources on the basis of the damage at those locations. This latter option is exercised whenever the on-base locations for certain types of personnel and equipment are *not* specified in the TSARINA data base. Furthermore, the TSAR-determined locations are always used in determining the environmental characteristics at the work and rest places when the effects of chemical protection are to be assessed. Properly applied, these *default locations* provide a reasonably rich and realistic representation of the on-base distribution of these nonstationary resources. When the default locations are used, the personnel and equipment loss rates that are used are those passed to TSAR from TSARINA for each of the specific facilities to which personnel and equipment may be assigned.

In brief, the TSAR *default-location* assumptions (summarized in Table 1 in the following subsection) presume that personnel for each of the several generic types of tasks will be found at their work place when they are working, and in other specific locations when (1) they are off duty, (2) they are on duty but unassigned, or (3) they are cooling off. On-equipment tasks occur at the aircraft, parts and equipment repair at the responsible shop, guided munitions assembly at shop #30, bomb assembly at facility #44, and civil engineering activity at whatever facility or surface is being repaired. Furthermore, there is a mechanism (see TSAR Card Type #37) with which the user can specify that each of these types of nonaircraft activity is actually carried out at a location randomly selected from a set of locations, according to the relative work load capacity at the locations. This notion of describing a "distributed" capability for an activity can also be used in defining the location assumptions that should apply for other personnel states (i.e., off duty, cooling off, and awaiting assignment). The next subsection will define these options in greater detail.

As indicated earlier, the user may choose to specify the locations of some types of personnel in his TSARINA data base and to depend on the TSAR default locations for the other types of personnel; this is perfectly permissible, but the user should remain aware that it is the default assumptions that will define the work and rest places, in either case, insofar as defining the environmental conditions for chemical warfare (CW) assessments.

The user has the same two options for specifying the location (and vulnerability) of support equipment at the time of an attack, except that the means of distinguishing between equipment that is assigned to a task and equipment that is unassigned are somewhat different. When the location of a particular type of equipment is indicated in TSARINA, the estimated percentage loss to that equipment type is applied in TSAR to all serviceable pieces of that type of equipment, whether or not they are in use. If, however, the user has set ONLYUE (only unassigned equipment) = 1 in the TSAR input on Card Type #2/1, the damage computed in TSARINA will be applied in TSAR only to the unassigned equipment. For equipment not specified in TSARINA, it is assumed to be at the shop to which it is assigned when not in use and at the work place when it is in use.

In addition to these general rules, a special procedure must be used for assessing losses to fuel trucks that are being refilled at the time of attack. The user specifies the target type that is to be used for these locations on the DATA card, and the average equipment loss probability at these locations is transferred to TSAR, where it is applied to whatever trucks are refueling at attack time. The only other additions to the general rules are that the vulnerability of reparable parts, and of munitions already committed to an aircraft, is determined by the damage sustained at the location of the appropriate tasks, rather than being based on damage data generated in TSARINA (the damage fraction estimated for "spare parts" at facilities engaged in munitions assembly are applied to the munitions).

TSAR DEFAULT LOCATIONS AND DISTRIBUTED CAPABILITIES

TSAR assigns all jobs to specific locations. These locations determine the work environment and are also assumed to be the location of personnel and equipment at the time of an attack (except when the default location has been overridden by specifying the personnel and equipment locations in the TSARINA data). The assigned location may be a specific building or outdoor area, or it may be a set of locations where a particular type of activity would be expected to be carried on. A particular "facility" number is set aside by TSAR for each of a variety of possible activities and functions that the user may wish to represent; all "facilities" from #1 through #50 have TSAR-assigned roles that will be explained in this subsection. The user may specify that the capability of any of these activities is actually "distributed," in which case the TSAR-assigned facility is only the first of a set of facilities to which that activity will be assigned; the user must define the other members of these sets (using facility numbers between #51 and NOFAC) and the relative capacity of each member of the set (or for backshops an absolute capacity for jobs may be specified) in the TSAR data base.

The much more limited capabilities in Early-TSAR for representing distributed functions still apply but have been expanded. As before, facilities #31, #32, and #33 are assumed to be the locations for on-duty flight line personnel (i.e., crew chiefs, specialists, and load crews from squadrons #1, #2, and #3, respectively) when they are not assigned to work on an aircraft; when assigned, they are either in the appropriate aircraft shelter or on the ramp where the aircraft is parked. Also, as before, on-duty backshop personnel who are not working are assumed to be in the shop with which they are associated (shops #1 to #24); unassigned wing-level munitions personnel are in shops #27 or #28, and unassigned munitions assembly personnel are in shop #30. In all cases, the facilities with the same numbers as the shop numbers, may each be the parent location of a set of locations into which that capability is "distributed."

Additionally, facilities #40, #41, #42, #43, #44, and #50 are now understood to be the parent locations for the following resource categories:

Facility #40	Aircrews; either all on-base crews, or if facility #41 is used (see TSAR Card Type #17/9) only those aircrews that are on-duty awaiting flight assignments.
Facility #41	Off-duty aircrews, when they are assumed to be at different locations than on-duty crews.
Facility #42	Unassigned on-duty civil engineers.
Facility #43	Unassigned civil engineering equipment.
Facility #44	Assembly of unguided munitions.
Facility #50	All off-duty personnel except aircrews.

Table 1 summarizes these default location assumptions that are used by TSAR.

The storage locations in the FACLTY array for #36 through #38 are reserved for use in connection with the repair procedures for aircraft shelters (no reference to a distributed capability is permitted with these locations). Facilities #46, #47, #48, and #49 are reserved to represent the buildings and equipment used to facilitate the rapid launching and recovery of aircraft, and facility #39 is reserved for an internal function.

Any facility (except #36 to #39 and #46 to #49) may be designated as the parent of a distributed set of facilities, each with its own physical and chemical characteristics, and its own relative capacity (specified by the user with the TSAR Type #37 Cards). Any additional facilities that jointly comprise a distributed capability must be numbered in the range from #51 to NOFAC. And other facilities in this range may be designated as collective-protection shelters, as discussed in connection with the TSAR Type #43/6 Card. The user must exercise care, however, that none of these additional facility numbers is defined in more than one way or appears in more than one distributed set, and *all such facilities must be present in the TSARINA data base* so that the relevant "damage" data will be transferred to TSAR. Since it is sometimes the case that elements of two or more functions occupy the same building, the effect on each element can be simulated by re-entering the building characteristics for each of the functions. When two or more TSARINA TGT cards with identical location, size, and orientation are listed together, TSAR is informed of this special relationship and repairs will be required for only the first building to reconstitute the several functions. If one of these "duplicate" facilities is an aircraft shelter, it must be listed first.

Table 1

TSAR DEFAULT LOCATION ASSUMPTION

Personnel Types	Personnel Location Awaiting Assignments	Working	Cooling Off	Off Duty
Aircrews	#40 . . .	In flight	NA	#41 (optional)
Flight line Squadron #1 Squadron #2 Squadron #3	 #31 . . . #32 . . . #33 . . .	Aircraft shelter or	Work location or #31 . . . or CP . . . fl	#50 . . .
Wing-level load crews	#27 . . . #28 . . .	Parking ramp		
Backshops and wing-level maintenance	Shop #1 . . . through #24 . . .	Specific facility	Work location or CP . . . bs	#50 . . .
Munitions Assembly Guided Unguided	 #30 . . . #44 . . .	Specific facility	Work location or CP . . . ma	#50 . . .
Civil Engineers	Personnel #42 . . . Equipment #43 . . .	Specific facility or Taxiway segment	Work location or CP . . . ce	#50 . . .

NOTES: Locations specified in TSARINA data for specific personnel types override these assumptions at attack time.

Shop #5 . . . implies Shop #5 and any locations to which the capability is distributed.

Location #51 to NOFAC (≤250) may be used to designate CPs and distributed capabilities.

Repair of specific part types may be restricted to "parent" shop.

Facilities #46, #47, #48, and #49 are reserved for use in conjunction with air traffic control.

DATA TRANSFER TO TSAR

The transfer of TSARINA results to TSAR involves a substantially more complex process than did the prior versions of these simulation models. In the original TSAR, Type #40 Cards were used for entering all attack damage data, and the formatting rules were straightforward. The data pertained only to conventional attacks and permitted the user to specify damage to each of the several classes of supporting resources (personnel, equipment, parts, munitions, TRAP, POL, and building materials) and also to specify damage to whatever base facilities were designated.

To account for CW attacks, as well as conventional attacks, the data transferred from TSARINA to TSAR with the Type #40 Cards are now much more complex. Except when a user wishes to represent the simplest kind of conventional damage that does not involve damage to the runways, taxiways, or aircraft, users should not attempt to prepare Type #40 Cards themselves, but rather depend upon TSARINA to generate the appropriate input for TSAR. The data now called for include not only the conventional damage data mentioned above but also the amount of surface contamination from each chemical agent at each shelter, on each taxiway segment, on each aircraft parking ramp, and at each of a set of monitoring points that the user has specified in defining the TSARINA data base. The Type #40 Cards are also now used to transfer the fraction of each personnel type that TSARINA associates with each monitoring point and each target type.

The user can no longer use a TSAR #40 Type Card to specify the number of repairs that must be made to open a runway, since this determination is now made internally within TSAR, rather than being transferred to TSAR from TSARINA (although TSARINA still makes the same determination for the individual attacks). TSARINA generates an entirely new dataset that is stored on disk and that includes location data for all craters on each runway, as well as the relative location of craters from attacks directed at the "MOS" for prior attacks, for each trial at each base. By storing data for the several attacks and then interpreting them within TSAR, a record can be maintained of all craters, and a crater is eliminated only when it has been repaired. This new dataset stored by TSARINA also contains a compact record of all the chemical deposition data for each of the monitoring points specified in the TSARINA data base. These data include the time from the attack until the chemical arrives at the monitoring point and the density of contaminants of each agent type that are deposited at each monitoring point. Furthermore, these data include a compact representation of the timewise variation of surface contamination and vapor concentration after the attack at each of the monitoring points. These various chemical data are stored for each component of each chemical burst that is assessed in TSARINA.

ENSURING RESOURCE CATEGORY COMPATIBILITY

The proper functioning of TSAR and TSARINA requires that the level of detail for the resource damage data that is output by TSARINA agree with that used in TSAR.

Although the available resource location data may require that one lump TSARINA damage assessments for some resource types into broad categories, such aggregate results are not useful in the TSAR simulation if these resources are treated in more specific terms in TSAR. Thus, one cannot specify "air-to-air" missile losses in the TSARINA output if TSAR differentiates between AIM-7s and AIM-9s.

The required consistency can be achieved in three ways. First, and most data intensive, TSARINA inputs may specify the location data separately for each type of munition that is to be distinguished in TSAR; that is, identical resource packets of AIM-7s and AIM-9s could be placed at the same locations in the TSARINA data base.

Second, when information as to the actual on-base locations is insufficient to permit differences in location to be differentiated, one can simply distribute resource packets of "air-to-air missiles" in the TSARINA data base, and then specify that the estimated damage to this commodity is to be reported to TSAR for the two specific missile types; the instruction that directs TSARINA to generate such a report is entered with an EQUIvalence card. If, for example, the user defines munitions #1 to represent air-to-air missiles in TSARINA, and defines munitions #7 and #9 to represent the AIM-7 and AIM-9 in TSAR, the user ensures that the damage estimate transferred to TSAR is interpreted correctly by stating that TSAR munitions #7 and #9 are equivalent to TSARINA munitions #1 with an EQUI card.

Third, when the on-base locations of many different types of a particular resource class cannot be distinguished, and the best that can be done is to estimate the same fractional damage for them all, the user can simply define resource packet locations for Type #0 resources. Type #0, for any particular class of resource, is interpreted to mean all members of the class *not otherwise specified*. Thus, if resource packets of munition Type #0 are located in the TSARINA data base (in addition to those for Type #1), TSAR would decrement the AIM-7 and AIM-9 stocks according to the damage estimated for TSARINA munition #1, and would decrement *all other* munitions by the TSARINA damage fraction estimated for Type #0 munition.

An example involving TRAP is outlined in Table 2:

The identity of the 200-gal tanks in TSARINA and TSAR would need to be defined with an EQUI card, as would the identity of the four types of pylons that are distributed similarly in various storage locations. But if TSAR dealt with only the 11 types of TRAP listed, the locations of the several type of racks could be defined simply

Table 2

USE OF EQUIVALENCE CARDS FOR TRAP DAMAGE DATA

Type of TRAP	Type-Number Specified in TSARINA Location Data	Type-Numbers as Understood in TSAR	User Action Required
200-gal tanks	#1	#21	EQUI data card
400-gal tanks	#22	#22	None
Pylons	#3	#11 #12 #13 #14	EQUI data card
Racks	#0	#1 #2 #3 #4 #5	None

by locating TRAP Type #0. The only EQUIvalence data needed would be to equate TSARINA TRAP #1 with TSAR TRAP #21, and TSARINA TRAP #3 with TSAR TRAP #11, #12, #13, and #14; the damage estimated for TRAP #22 and TRAP #0 would be passed to TSAR where the latter damage fraction would be applied to each of the five types of racks listed.

When dealing with personnel and munitions, two other special features come into play. The first of these is concerned with the distiction between on-duty and off-duty personnel, which are treated differently within TSAR. To indicate that a particular category of personnel is off duty, the number 1000 is added to the nominal personnel type when their location data are entered.[2] When this is done, casualties among on- and off-duty personnel are estimated separately in TSARINA and reported separately to TSAR without any additional user input. Specification of personnel Type #1000 implies all off-duty personnel types that are not otherwise specified.

The other special number convention permits the user to distinguish the locations and damage to assembled munitions and complete sets of components for unassembled

[2]TSAR and TSARINA storage arrays for personnel data are dimensioned for NOPEOP different types of personnel, excluding aircrews, where NOPEOP may be anything from 1 to 320. When on- and off-duty aircrews are to be located in a TSARINA data base, they are identified for TSAR as the "NOPEOP+1"th personnel type for on-duty aircrews, and the "NOPEOP+1001" personnel type for off-duty aircrews.

munitions; unassembled sets of munition components are identified simply by adding the value of the munitions array dimension NOMUN to the nominal munition type designation. However, if the user distinguishes the various components from which a complete round is assembled, the normal number for the components should be used to identify their location. Thus, if munition #5 is an assembled PGM-X, and NOMUN is 200, munition #205 would refer to complete sets of unassembled PGM-X components. Munition #14, on the other hand, might comprise one component #37, one component #44, and three components #51; those components would be identified by their numbers; the value NOMUN should not be added.

These special identity numbers for personnel and munitions may either be assigned to the resources when their location data are specified, or subsequently, using the EQUIvalence card type.

IV. CONVENTIONAL WEAPON EFFECTIVENESS DATA

TSARINA may be used to assess attacks that involve three different classes of weapons: point impact weapons, area munitions, and chemical weapons.[1] The basic mathematical representation for each of these weapon types is quite different and involves substantial approximations, as will be discussed. For general-purpose (GP) bombs, for example, no attempt is made to capture the variation of blast pressure and fragment density with distance from the impact point; rather, these detailed phenomena are approximated as circular areas of constant effectiveness, with what have often been called "cookie-cutters." Since the main objective of the TSARINA Monte Carlo damage assessment model is to generate airbase attack outcomes that exhibit realistic levels of damage variability across trials—not to accurately estimate the damage to any particular target for a particular impact point—that result can be achieved with "cookie-cutters" as long as the volume of destructive effects is equivalent to the mean-area-of-effectiveness (MAE)[2] for the target-weapon combination.[3] The approximations for area weapons and chemical weapons are similar in that they do not attempt to capture the fine-grain effects, but only seek to preserve the overall damage effects.

Although the basic TSARINA effectiveness representations are relatively simple and straightforward, there is such a large number of options and variations that this section must be studied carefully if one is to avoid difficulties. The procedures presented

[1]Weapons that combine point-impact munitions and area munitions, such as the JP-233, may also be treated.

[2]The key source materials for weapons effectiveness data are those published by the Joint Technical Coordinating Group for Munitions Effectiveness in various Joint Munitions Effectiveness Manuals; the Target Vulnerability volumes, and the BASIC JMEM/AS will be the primary sources for TSARINA analyses.

[3]The temptation to represent the damage potential of weapons with, for example, a bivariate normal distribution in order to more faithfully reflect detailed engineering estimates has two problems; first, any well-behaved mathematical function is at best itself an approximation of the truth, and for fragmentation weapons would often be a relatively poor approximation; and second, the computer processing required to estimate the average value of the normal distribution over some portion of a rectangular target is substantial. As long as the volume under the distribution is equal to the MAE for the target-weapon pair under consideration, the shape of the distribution is secondary since our purpose is to generate damage patterns that reflect realistic variability from trial to trial.

here provide the means by which the user is able to represent the effectiveness of up to 20 types of weapons against as many as 30 different types of structures, and to differentiate the expected damage to the structures, and to each of up to six classes of resources that may be associated with each type of structure, for direct hits and for near misses.

POINT-IMPACT WEAPONS

Several different types of conventional weapons can be represented as "point-impact" weapons. General-purpose bombs and precision-guided munitions (PGMs) can be handled this way. Various types of munitions that deploy patterns of submunitions, such as boosted kinetic energy penerators (BKEP) delivered by surface-to-surface missiles, aircraft, or cruise missiles, can also be treated this way in TSARINA; the weapons effects data discussed here apply to the individual submunitions.

For each kind of point-impact weapon, an effective miss distance (EMD) is specified for each target type (i.e., that miss distance at which the weapon is effective and an impact is to be categorized as a hit).[4] When this is done, target coverage is computed as that fraction of the target area that is covered by a circle having a radius of EMD and is centered at the impact point. That fraction is interpreted as the damage to the structure itself. This is illustrated in Figure 2a by the areas a1 and a2, where R1 = EMD. In this case the fractional damage to the structure as a result of the two impacts is a1/A and a2/A; the total damage is assessed as

$$1.0 - (1.0 - a1/A) \times (1.0 - a2/A)$$

or in general the fractional damage is:

$$FD = 1.0 - \Pi(1.0 - C_{w,t(i)})$$

where $C_{w,t(i)}$ is the target coverage based on the EMD of the *ith* hit on a target of type t by a weapon of type w.

The expected damage to the contents of the structure can be estimated in eight different ways, and the manner in which those estimates are made can be different for each of the six classes of resources: personnel, equipment, aircraft spare parts, munitions,

[4]A "direct hit" is specified when the impact point is within the target perimeter; all other hits that influence the target are defined as "near misses."

TRAP, and building materials. The simplest means of estimating damage is illustrated in Figure 2b; in this case (that will subsequently be identified by FLAG=1), the user specifies the average damage fraction expected within the radius R1 for each resource class, and the expected fraction of that resource damaged is then $Pk \times a1/A$ for the near miss and $Pk \times a2/A$ for the direct hit. The total damage is again taken to be:

$$1.0 - (1.0 - Pk \times a1/A) \times (1.0 - Pk \times a2/A)$$

Alternately (FLAG =2), the user may specify a second radius, R2, as well as an expected damage level, Pk, within that radius for each resource class; this option is illustrated in Fig. 2c. In this instance, the fractional damage to a resource in the structure is $Pk \times a1/A$ and $Pk \times a2/A$ for the two near misses, and the total damage is assessed in a manner analogous to that indicated for Fig. 2b. A variant on this option (FLAG=3) neglects the coverage within R2 for weapons that did not fall within R1 of the structure. In this case, the contribution of a2 in Fig. 2c would be taken as zero. This option was introduced to crudely approximate the situation in which the walls of a facility would protect the contents if the facility did not suffer structural damage (i.e., was not within R1 of the impact), but when the facility was broached the contents would be damaged within a radius of R2.

Another option for assessing resource damage is illustrated in Fig. 2d; in this case (FLAG=4) the user specifies another radius R for each resource class and all contents within that radius are taken to be damaged; i.e., Pk = 1.0. Thus, in this case, the damage is a1/A and a2/A. This option also has a variant (FLAG=5) for which the target coverage is neglected if the impact is not within R1 of the target.

Since representing the distribution of target vulnerability with a simple cookie-cutter admittedly is an extremely rough approximation, we also introduced what could be called a "two-layer cookie-cutter" to provide the user with options that will permit somewhat greater fidelity in representing target vulnerability (while retaining computational simplicity). There are three options for estimating resource damage that use the two-layer cookie-cutter representation. The first of these (FLAG=6) is illustrated in Fig. 2e; in this case, the user specifies both a radius and a damage probability for each resource class. For each impact, the target coverage within R1 is estimated as area a11, and within R as area a1, and the expected resource damage fraction is taken as

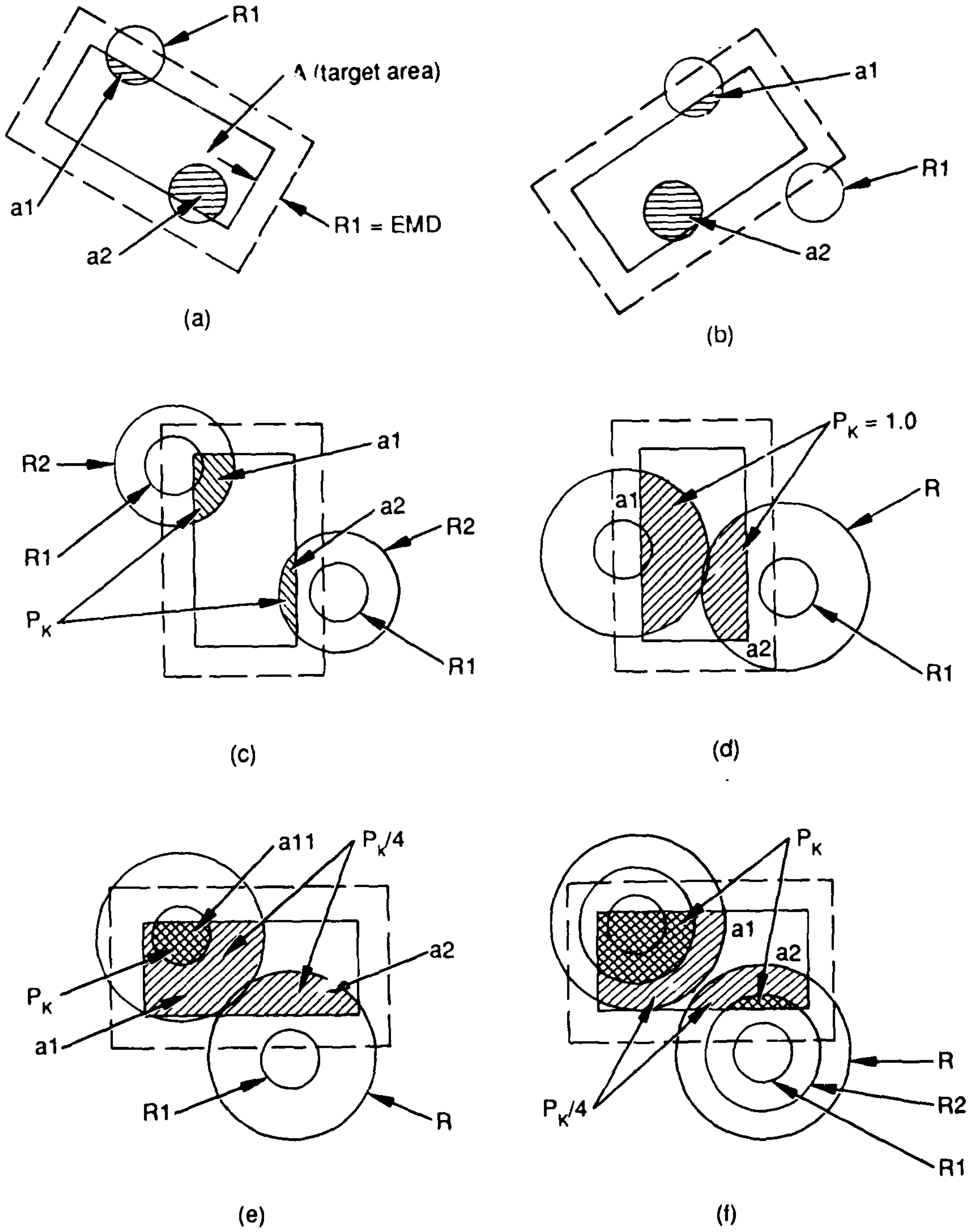

Fig. 2—Point-impact weapon coverage estimation options

$$Pk \times a11/A + (Pk/4) \times (a1 - a11)/A$$

Thus, the damage is taken to be Pk within the radius R1 and Pk/4 within the annular area between R1 and R, and the total damage as estimated as before using the independence assumption for the several individual damage fractions. The factor of *1/4* for the relative damage probability in the annular area between R1 and R is fixed in the code and may not be varied by user input.

The final options available for representing damage to resources in the structure are illustrated in Fig. 2f. In this instance, the user specifies the damage probability within the inner area defined by R2, and the radius R for each class of resource. The damage fraction is analogous to that for Fig. 2e—Pk within the area covered by the inner radius and Pk/4 within the annular area between R2 and R. With the FLAG=7 option, all target coverage by R2 and R is taken into account, whereas for FLAG=8 only those impacts that fell within R1 of the target perimeter are counted toward the total resource damage fraction. In the instance illustrated, only the upper hit would be counted for FLAG=8.

With these various features, one uses the EMD (i.e., R1) to represent the radius of the MAE for structural damage to a structure, and has the eight options for representing the MAE for damage to the contents. Furthermore, these various factors—R1, R2, and R as well as the Pk values—may be assigned different values for hits within the target perimeter and for hits outside the perimeter. The final results include the cumulative structural damage fractions for each target for all types of point-impact weapons that fell on or near the target, as well as the cumulative damage fractions for each of the six resource classes, computed according to the relation:

$$PK = 1.0 - \Pi(1.0 - C_{r,w,t(i)})$$

where $C_{r,w,t(i)}$ is the damage fraction to resource class r that resulted from the i*th* hit on or near the target of type t by a weapon of type w.

The data required to define how TSARINA is to estimate the various damage fractions for point-impact weapons are specified with the EMD card (see App. A). Altogether up to 17 different values may need to be specified for a particular target type for a given weapon. To permit the user to specify these various data, the EMD card may be followed by up to 16 supplementary cards. The actual data format used for these cards is illustrated in Fig. 3. Since there may be up to 30 different types of targets, and only 10 can be accommodated on a card, the (up to) 17 cards associated with a particular weapon may need to be repeated two or three times to include all relevant target types.

						Target Types						
			1	2	3	4	5	6	7	8	9	10
[1]	EMD	W#	zz	xx	xx	R1	xx	xx	xx	xx	xxx	xx
[2]				xx	xxx	R2	xx	xx		xx		xxx
[3]			xx	xx	xx	Personnel		xx	xx	xx	xx	xx
[4]			xx	xx	xx	Equipment		xx	xx	xx	xx	xx
[5]	(*)			xx	xx	Parts		xx	xx	xx	xx	xx
[6]	(*)			xx	xx	Munitions/POL			xx		xx	
[7]					xx	TRAP				xx		xx
[8]				xx	xx	Materials			xx		xx	
[9]			—	—	—	—	FLAGs		—	—	—	—
[10]			xx	xx	xx	R1 for direct hits					xx	
[11]				xx	xx	R2 for direct hits				xx		xx
[12]			xx		xx	Personnel					xx	
[13]				xx		Equipment				xx		
[14]						Parts						
[15]						Munitions/POL				xxx		xxx
[16]				xx		TRAP			xx	xx	xxx	
[17]				xx	xx	Materials				xx		xx

*For target types that the user has designated as taxiways and aircraft parking ramps, the entries for "spare parts" and "munitions" are interpreted to refer to aircraft damage and aircraft kill, respectively. Also, since munitions and POL would not be expected to be present together, little flexibility is lost with the dual definition used with the 6th and 13th cards; it is important, of course, that the user be clear as to the distinction.

Fig. 3—Illustrative EMD card image format for point-impact weapons

The bracketed numbers at the left are simply the card count and would not appear in the actual data entry. The values of R1 for the first ten targets types are entered on the first card. The weapon type is also identified on this card (W#). Since target type #1 is reserved in TSARINA for flight surfaces, the R1 value for this target type is interpreted as the crater radius for this weapon against the flight surfaces; denoted here as "zz." The values of R2 are entered on the second card.[5] The special entries for the six resource

[5]Several special factors are entered on the 1st and 2nd cards but are not illustrated here in interest of clarity; they include the total number of cards associated with the particular weapon type and the reliability of the weapon. A special entry on the second card can be used to designate that some percentage of the "reliable" point-impact weapons are UXO that require different treatment from ordnance that detonates; another designates the distance from taxiways and ramps within which UXOs must be cleared for safe aircraft operations. If all unexploded weapons are to be counted as UXO, the weapon "reliability" should be set to one.

classes follow on cards 3 through 8; in many cases entries would not be appropriate since certain resources would never be found associated with certain target types. Ammunition and TRAP, for example, would never be found stored on flight surfaces. The nature of these entries depends upon the particular method that is to be used to assess resource damage, i.e., the FLAG. The entry would be a Pk for FLAGs 1, 2, and 3 and would be a radius for FLAGs 4 and 5. For FLAGs 6, 7, and 8, the entry is a composite number; it is equal to 1000 times a radius plus a Pk. The entries on the 9th card are a six-digit number for each target type, where the value of each digit denotes the FLAG for a resource; digit 1 for personnel, digit 2 for equipment, etc. Hence, an entry of 772345 would specify that personnel and equipment losses are to be computed in accord with the procedure for FLAG 7, and the losses for parts, munitions, TRAP, and materials according to the procedures for FLAGs 2, 3, 4, and 5, respectively.

The various values specified on the first eight cards apply to direct hits and near misses, except when a data entry occurs on cards 10 through 17 for a particular target type; in that case the values on cards 10 to 17 apply to a direct hit, and those on cards 1 to 8 are used only for near misses. Thus, in Fig. 2c the values specified on cards 10 through 17 are applied to the direct hit (i.e., a11), and the values from cards 1 to 8 are applied for the near miss (i.e., a2). The value of the FLAGs apply for both situations. It is important to note that if any data are entered below card 9 for a particular target type, only data from cards 10 through 17 will be used to assess direct hits; i.e., a null field will be interpreted as zero.

Since there may be up to 30 target types, additional sets of (up to) 17 data entry cards will be required for targets 11 to 20 and 21 to 30. The actual number of cards in each set is determined by the user's needs; if the user doesn't wish to differentiate between direct hits and near misses, nine card images are sufficient. The number of supplementary cards to be used with each EMD card is identified in a special field (not shown here) on the first card.

Aircraft Shelters

Estimates of damage to aircraft shelters and their contents are based both on the weapon effectiveness data entered for the target type of the aircraft shelter and, when used, the special effects associated with hits on a "pad" in front of the shelter door. For the data entered for the shelter itself, no distinction is made between a direct hit and a near miss; the entry on the 1st EMD card is interpreted as the effective miss distance against aircraft in shelters with closed doors, and the entry on the 10th card is interpreted as the effective miss distance against aircraft in shelters with open doors. The entries on the 2nd through 9th cards are used to assess losses to resources in a closed shelter in a manner consistent with other target types, as just explained. The probabilities that aircraft are damaged and aircraft are killed in closed and open shelters, and the probability that the shelter itself is lost, are given by the entries on the 12th through 16th cards (see App. A). When a "PAD" card (App. A) has been entered for aircraft shelters, hits on that surface increase the damage to the shelter and to the contents when the door is open. The special interpretations for the EMD card and the entries for the PAD target type are explained in App. A.

DISPENSER MUNITIONS

Several types of aircraft munitions have been developed or are under development, that package large numbers of small bomblets and/or small antipersonnel/material mines in large cannisters and that can be delivered over a target area by aircraft. Each aircraft may carry one or more of these cannisters, which may be designed to release the submunitions while still attached to the aircraft or after having been dropped, much like an ordinary bomb.[6] In TSARINA, these kinds of munitions are simulated by assuming that the patterns of effectiveness for each dispenser can be approximated with a rectangle of uniform effectiveness.

When weapons are specified as dispenser weapons, the model first computes the fraction of the area of each target that is covered by the rectangular bomblet pattern. The total fractional coverage of a target for all passes is that fraction of the area that has been covered by one or more patterns. If a probability of kill is associated with "coverage" by patterns for different resource classes, the model will generate the total probability of kill, taking into account the actual position of each of the CBU patterns that covered any portion of the target, according to the relation:

$$PK = 1 - \sum_{i=1}^{T} \left\{ \prod_{a=1}^{M} \left[i - P_{k_{w,t}} \right] N(a,i) \right\} / T,$$

[6]Some dispenser designs deploy both point-impact submunitions and large numbers of small bomblets or mines; these may also be simulated with TSARINA.

where

a = the attack number,

i = a point on the target grid,

$N(a,i)$ = the number of times point i was "covered" during attack a,

M = the total number of CBU attacks,

T = the total number of target grid positions, and

$p_{k_{w,t}}$ = the probability of kill of a portion of a target of type t that is "covered" by a bomblet pattern from a weapon of type w.

The results for each trial include the number of hits by point-impact weapons and the fractional coverage by dispenser weapons for each target as well as the estimated damage fraction for each resource class due to the point-impact weapons and the dispenser weapons.

The entries on the EMD card for dispenser munitions specify the weapon type, the reliability of the dispenser, the down-range and cross-range dimensions of the rectangle, the number of mines included in the dispenser payload, and the "influence" diameter of individual mines. Specific data are not required regarding the number of bomblets that are included in each dispenser; the effects of these bomblets detonating on impact will be approximated by an average damage probability within the rectangular coverage area.

The ATT card specifies how many of the dispensers are released during an attack and the spacing of the releases. TSARINA integrates these data as noted above to estimate the total coverage of each rectangular target by dispenser patterns. These data are interpreted as the number of "coverages" for each target; for taxiways, the results also include the number of mines that have fallen on, or within the "influence" radius of, each taxiway (this radius should be selected to indicate how far off a taxiway mine will need to be cleared for safety).

In addition to estimating the dispenser "coverage," additional data may be entered to define the average probability of damage to personnel, equipment, spare parts, munitions, TRAP, and building materials from the exploding bomblets. These data are entered with supplementary cards for each dispenser EMD card. The user may enter up to seven supplementary cards; the first must be blank, and the entries on the 2nd through 7th supplementary cards are interpreted as the percentage of the six classes of resources that would be expected to be lost if the bomblet pattern covered their location. These data are entered separately for each type of target. Intermediate cards must not be omitted; e.g., if only equipment and TRAP losses were of interest, two blank supplementary cards would have to precede the 3rd card (for equipment) and two more blank cards would need to precede the 6th card (TRAP). If more than the first ten target types are defined, a second (and third) set of (up to) six supplementary resource damage cards for the 11th through 20th (and 21st through 30th) target types must be appended immediately following those for the first ten.

An important exception to these rules occurs for those target types designated as taxiways and ramps; the damage probabilities that should be entered on the supplementary cards for the third (parts) and fourth (munitions) resources for these target types are the probability that an aircraft in the open is damaged, and the probability that an aircraft in the open is killed. After the combined effects of all the attack weapons have been estimated for the taxiways and ramps, the values for "parts" and "munitions" are transferred to TSAR as the probability of aircraft damage and kill.

If the rectangular approximation of a disperser pattern is judged too unrealistic, the user may prefer to use the TSARINA capability to simulate a controlled pattern of point-impact submunitions. The current formulation permits each submunition package to contain up to 400 independently targeted submunitions.

V. CHEMICAL ATTACKS

Airfields may be attacked with chemical agents by aircraft or surface-to-surface missiles. Aerial-delivered chemical munitions include modified conventional unitary and cluster bombs, specially designed spray bombs, spray tanks, and air-to-surface missiles. The chemical weapons would generally be airburst (over or upwind of the airfield), creating an immediate vapor and liquid hazard from the falling, evaporating agent droplets and a residual hazard from both the liquid droplets on the ground and vapor from evaporation of those droplets.

Surface deposition patterns of the droplets depend upon a number of factors: agent release parameters (e.g., altitude, shape, size, and orientation of the initial agent droplet cloud), meteorological parameters (e.g., wind velocity and direction as a function of height, ambient air temperature, atmospheric stability parameters), and agent parameters (e.g., density, diffusivity, saturation concentration, droplet diameter distribution). The contours of surface deposition patterns vary from the nearly rectangular shapes of aircraft spray tanks releasing agents perpendicular to the wind direction to the cigar-shaped patterns created by ballistic missiles.

Each of the delivery systems has constraints on the delivery parameters (e.g., the nearly vertical trajectory of ballistic missiles or a requirement for low-altitude penetration of air defenses by aircraft). However, within the constraints imposed by the delivery system, chemical munitions will generally be designed to release their agent fill at altitudes that tend to maximize some value of a real coverage by agent deposition on the ground (e.g., to maximize the area covered by a density of $100 mg/m^2$ of agent).

Deposition patterns can be obtained from test data or from computer models of atmospheric transport, dispersion, and evaporation of liquid droplets. Two such models are NUSSE2 [15] and the model described in [16].

REPRESENTATION IN TSARINA

In TSARINA, a deposition pattern is normally represented by a set of up to 17 rectangular "layers"; alternatively, the pattern may be represented by a set of ellipses, or for spray tanks used on a flight path that is not normal to the wind, by parallelograms.

The pattern has a wind velocity associated with it and a reference point (nominally, the burst point of the chemical weapon) from which the rectangles (ellipses) are offset. The patterns are perpendicular to the wind direction, but otherwise have arbitrary relative locations and sizes. Each pattern has a constant contamination density and the total contamination density at a point is the sum of the densities for the rectangles containing the point.

Figure 4, from [16], contains surface deposition contours produced by the surface deposition model of that reference for the TMU 28/B aircraft spray tank delivery system. Figure 5 illustrates the fitting of the contours of Fig. 4 by rectangular layers for use in TSARINA. The values of surface deposition associated with the rectangles in Fig. 5 were chosen so that the average value of surface deposition over the area of each rectangle approximates the actual average value within the corresponding contour of Fig. 4 (as obtained from a curve of area versus surface deposition in [16]). Thus, for example, the average surface deposition value within the $500 mg/m^2$ contour is approximately $610 + 228 + 41 = 879 mg/m^2$.

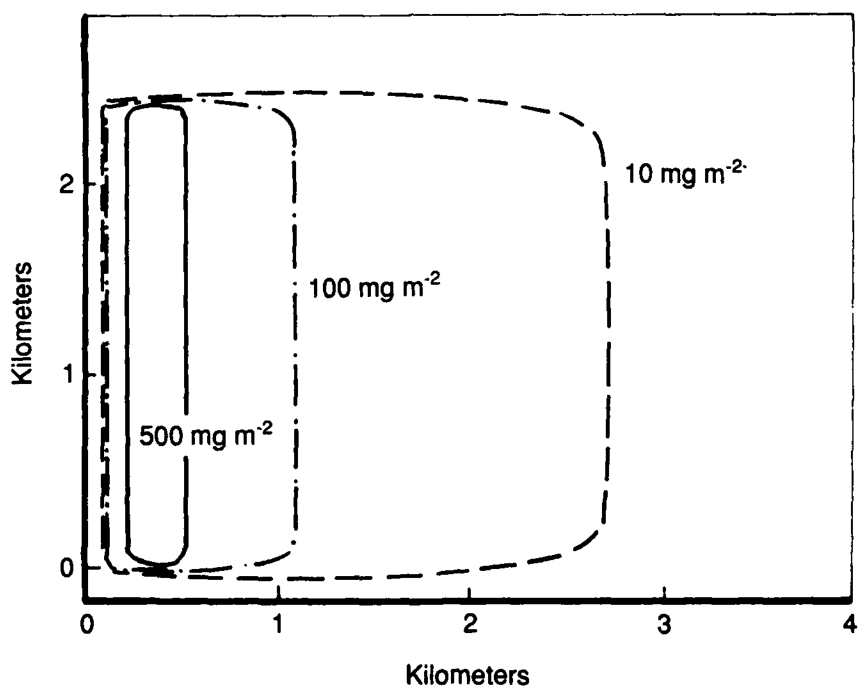

Fig. 4—Surface deposition contours for the TMU 28/B aircraft spray tank delivery system [15]

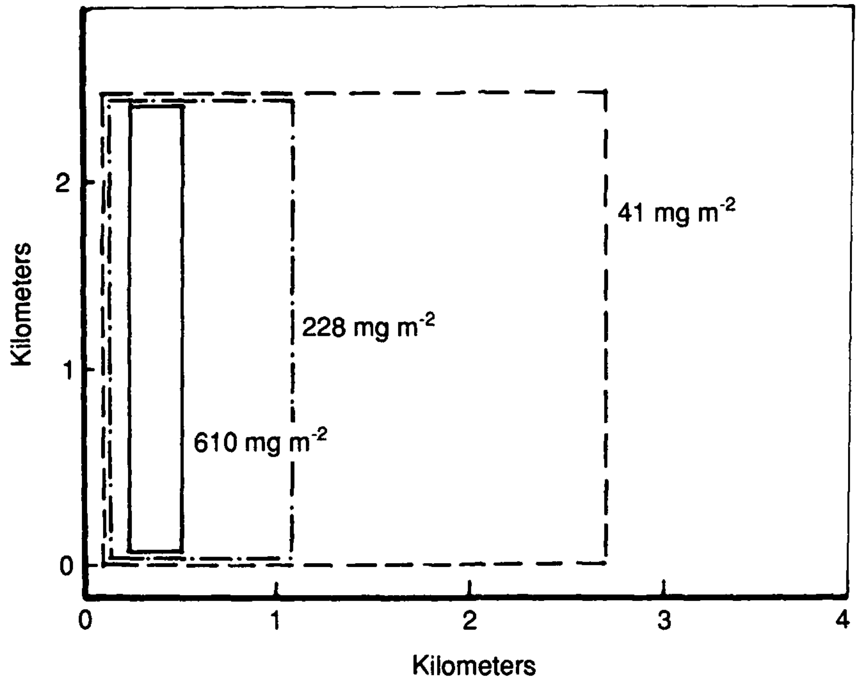

Fig. 5—Illustrative fit to the surface deposition contours of Fig. 4 by rectangular layers

In the model we use for vapor densities over and downwind of the pattern, the vapor densities depend upon the mass median diameter (MMD) of the droplets in the surface contamination. Each rectangle (ellipse) has two MMDs, one for the upwind half of the rectangle (ellipse) and one for the downwind half (large droplets fall faster than small droplets so that the average MMD in the upwind half of the rectangle (ellipse) is larger than that of the downwind half).

The first EMD card is used to enter these data for the largest of the several rectangular (elliptical) layers. A "-1" in columns 17–18 of this EMD card distinguishes the data as those for a chemical weapon. A supplementary EMD card is added following the EMD card to define the characteristics of each of the other layers (a maximum of 16 supplementary cards).

Delivery parameters for each weapon delivery pass are defined with an ATT card and include: attack heading, heading uncertainty, the desired mean point of impact of the pattern reference point (for a single weapon or for the middle of a stick of weapons), the aiming error expressed as REP (range error probable) and DEP (deflection error probable), the ballistic error (REP and DEP) of the individual weapons, the number of weapons to be delivered in the pass, the stick length, the probability of arrival of the weapon system at the target and the weapon reliability. Monte Carlo procedures are then used to determine the arriving weapons and the locations of the reference points for the surface deposition patterns. The wind direction and velocity at the time of the attack are then determined by sampling from uniform distributions using the mean direction and direction range, and mean velocity and velocity range as inputs. The downwind offsets and dimensions of the pattern rectangles are scaled by the ratio of the sampled wind velocity to the nominal wind velocity for the pattern.

MONAGHAN AND MCPHERSON ROUGH SURFACE EVAPORATION MODEL

Several models exist for estimating surface evaporation of chemical agents [17, 18]. We have adopted for use in TSAR/TSARINA a version of the rough surface evaporation model developed by J. Monaghan and W. R. McPherson [18]. This model estimates both the residual surface deposition and the evaporation-created vapor threat over and downwind of the contaminated area.

Meteorological conditions (temperature, wind velocity and direction, and atmospheric stability), chemical/physical properties of the agent, type of surface, and the liquid loading are the primary factors affecting evaporation rates and the resulting downwind vapor. Higher temperatures and wind velocity increase the evaporation rate but higher wind velocity may actually decrease the downwind vapor concentrations. The other factors affect evaporation or absorption rates or the downwind dispersion of the vapor.

The parameters representing these factors that enter directly into the Monaghan and McPherson rough surface evaporation model are:

SD The initial surface contamination density (mg/m^2).

Ma Mean liquid loading on the rough surface (mg/m^2).

P Transport velocity between surface liquid film and internal sink (i.e., absorption velocity) (m/sec).

P0,P1 Vapor transport velocities between the bottom and top of the rough surface and the turbulent air stream, respectively (m/sec).

Pa Mean transport velocity between the surface and the turbulent air stream (m/sec).

Cs Saturated vapor concentration at the temperature of the surface (gm/cc).

PSC Pasquill stability category (C,D,E,F).

Although the Monaghan and McPherson model could be used for evaporation from other surfaces, it has only been applied to grasslands. Reference [18] contains model parameters selected to fit test data for evaporation from grasslands, and this is the version of the model used for TSAR/TSARINA. Liquid droplets sprayed on grassland form liquid films on the grass and underlying debris. The thickness of the films decreases with increasing height and is an order of magnitude larger near the top of the grass than at the bottom. Ventilation of the surface by the turbulent atmosphere increases from the ground to the top of the grass. The evaporation rate is proportional to the area covered by liquid film and is constant until the thinner films at the top of the grass are completely evaporated. The time during which the evaporation rate is constant is called the steady-state time T. Its value is

$$T = M1/(Cs(P1 + P))$$

where M1 and P1 are the thickness of the film and the transport velocity into the atmosphere at the top of the grass, respectively. The evaporation rate continues to decrease after the steady-state time until the time τ when all of the films have evaporated. τ is equal to

$$\tau = M0/(Cs(P0 + P))$$

where M0 and P0 are the thickness of the film and the transport velocity into the atmosphere at the bottom of the rough surface, respectively. The ratio M1/M0 was found to be approximately 10 for a variety of field trials on grasslands. Assuming M1/M0 = 10 and linearity of film thickness over the height of the grass, i.e., Ma = (M0 + M1)/2, we have

$$T = (Ma/5.5)/(Cs(P1 + P)) \tag{1}$$

$$\tau = (10Ma/5.5)/(Cs(P0 + P)) \tag{2}$$

The transport velocity between the rough surface and the turbulent air stream is assumed to increase linearly between the bottom and top of the rough surface. For grasslands, Pa, the average transport velocity between the surface and the turbulent airstream is approximated as $Pa = 0.01 \times u(2)$, where u(2) is the wind speed at 2 m above the surface. P0, the transport velocity at the bottom of the surface, is the transport velocity in slight air motion and is approximated as 5 cm/min or 0.00083 m/sec. Thus, for grassland, $P1 = 2Pa - P0 = 0.02u(2) - 0.00083$. The transport velocity for absorption of the surface liquid by the surface material, P, depends upon the surface and the agent. For grasslands, P has values ranging from 5 to 200 cm/min for a typical set of chemical agents.

The initial mean liquid loading on the rough surface, Ma, is assumed to be uniform throughout the contaminated area. Presumably, Ma depends upon the agent, the surface deposition density, the surface, and the droplet size distribution. However, Monaghan and McPherson found no evident relationship between Ma and these factors for grasslands. Rather, they recommended using only a few different values for Ma, depending upon chemical weapon type. In TSAR/TSARINA, we use the equation for Ma used in the NUSSE2 model:

$$Ma = \rho \times MMD/(0.0015 \times SF \times SF)$$

where ρ is the density of the agent at the temperature of the surface, MMD is the mass median diameter of the agent, and SF is the spread factor of the droplets. This equation can be derived by assuming approximately spherical droplets of diameter MMD that spread by a factor of SF upon hitting the surface.

Steady-State Vapor Density from Uniformly Contaminated Areas

Monaghan and McPherson have developed a graphic technique for approximating the vapor concentration over and downwind of uniformly contaminated rectangular areas perpendicular to the wind direction for the grassland model of [18].

Several of the quantities defined in the following are dependent upon the "Pasquill stability category." In [19], Pasquill defines qualitatively six categories of atmospheric stability: from A through F, varying from very unstable, A, through neutral, D, to stable, F. According to Pasquill, stability can be related to wind speed and either insolation by day or cloud cover at night as shown in Table 3.

Insolation is estimated from solar elevation and cloud cover. With clear skies, strong insolation corresponds to an elevation greater than 60° and slight insolation to an elevation between 15° and 35°. Strong insolation is reduced to moderate by broken

Table 3

PASQUILL STABILITY CATEGORY

Surface Wind Speed at 10 m	Surface Wind Speed at 2 m	Day Insolation Strong	Day Insolation Medium	Day Insolation Slight	Night Cloud Cover ≥4/8	Night Cloud Cover ≤3/8
					> 4/8	< 3/8
< 2	< 1.5	A	A–B	B	—	—
2 – 3	1.5 – 2	A–B	B	C	E	F
3 – 5	2 – 3.3	B	B–C	C	D	E
5 – 6	3.3 – 4	C	C–D	D	D	D
> 6	> 4	C	D	D	D	D

medium cloud cover and to slight by broken low cloud cover. Category D should be assumed for overcast conditions day or night. Night refers to the period an hour before sunset to one hour after sunrise.

The graphic method described in the following is applicable only for categories C through F.

(1) Infinite crosswind dimension of the contaminated area

(a) For locations inside the contaminated area:

$$C(x;z) = F1(x;z) \times Cs \times Rf(x;P/Pa) \times SD/(0.2 \times Ma) \qquad (3a)$$

where C(x;z) is the vapor concentration at a distance x from the upwind limit of the contaminated area at a height z meters above the surface (in TSAR we use only the values for z = 1.5m), F1(x;z) and Rf (x;P/Pa) are graphed quantities, Cs is the saturated vapor concentration at the temperature of the surface, SD is the surface deposition density, and Ma is the initial mean liquid loading. F1(x;z) depends upon x, z, and the stability category; Rf(x;P/Pa) depends upon x, P/Pa, and the stability category.

(b) For locations downwind of the contaminated area:

$$C(x) = F2(x/x0;P/Pa) \times Cs \times Rf(x0,P/Pa) \times SD/(0.2 \times Ma) \qquad (3b)$$

where C(x) is the maximum concentration between the ground and a height of 2 m at a distance x from the upwind limit of the contaminated area, F2(x/x0;P/Pa) and Rf(x0;P/Pa) are graphed quantities, x0 is the downwind dimension of the contaminated area, Cs is the saturated vapor concentration at the temperature of the surface, SD is the surface deposition density, and Ma is the initial mean liquid loading. F2(x/x0;P/Pa) is dependent upon x/x0, P/Pa, and the stability category; Rf(x0;P/Pa) depends upon x0, P/Pa, and the stability category.

In TSARINA, values of F1(x;z), F2(x/x0,P/Pa), and Rf(x/P/Pa) are determined by interpolation in tables of values read from curves of these functions.

(2) Finite crosswind dimension of the contaminated area.

As vapor is transported downwind from a point source, it is dispersed in the crosswind direction by atmospheric diffusion. The crosswind vapor concentration distribution is assumed to be a Gaussian distribution centered on the downwind location from the point source with a standard deviation S that is increasing with the downwind distance x, as derived from Pasquill's parameters for vapor cloud widths from point sources as given in Table 4.

The vapor concentration, C(x,y,z), at a height z and at a downwind distance x and a crosswind distance y from the center of a uniform line source of length Y0 is

$$C(x,y,z) = C1(x,z) \times (N((Y0/2 - y)/S) - N((-Y0/2 - y)/S))$$

where N( ) is the Gaussian distribution with zero mean and unit standard deviation, and C1(x,z) is the vapor concentration at a height z and a downwind distance x from a uniform line source of infinite length.

Table 4

FORMULAS FOR CROSSWIND DISPERSION STANDARD DEVIATIONS

Stability Category	Standard Deviation	
C	$S = 0.176 \times x^{0.923}$	$x \le 3000$ m
	$= 0.254 \times x^{0.877}$	$x > 3000$ m
D	$S = 0.0964 \times x^{0.960}$	$x \le 3000$ m
	$= 0.260 \times x^{0.836}$	$x > 3000$ m
E	$S = 0.0839 \times x^{0.931}$	$x \le 3000$ m
	$= 0.148 \times x^{0.860}$	$x > 3000$ m
F	$S = 0.0543 \times x^{0.939}$	$x \le 3000$ m
	$= 0.105 \times x^{0.857}$	$x > 3000$ m

At a height of z and a distance x downwind from the upwind edge and a distance y crosswind from the center of a uniformly contaminated finite rectangular area of dimensions X0 and Y0, the vapor concentration, C(x,y,z), is approximated as

$$C(x,y,z) = C2(x,z) \times (N((Y0/2 - y)/S) - N((-Y0/2 - y)/S)) \qquad (4)$$

where C2(x,z) is the vapor concentration at a height z and a downwind distance x from a uniformly contaminated area of infinite width (e.g., Eqs. (3a) or (3b), and S is evaluated at max(x/2,X0 – x/2) from the equation above with the appropriate stability category).

Vapor Concentrations from Nonuniform Surface Deposition

In TSARINA, nonuniform surface deposition patterns are represented by a set of rectangular (elliptical) layers each of which has a uniform deposition. In TSAR, the vapor concentration from the surface deposition is then approximated as the sum of the vapor concentrations from each of the rectangular (elliptical) layers.

Monaghan and McPherson have extended their computer model for computing residual surface deposition and vapor concentrations from uniformly contaminated areas to nonuniformly contaminated areas. In the following, we use an example to illustrate the fitting of rectangles to a nonuniform deposition pattern and show the resultant approximation for vapor concentrations. Figure 6 contains an example for the surface deposition from an aircraft spray tank. The surface deposition is uniform in the crosswind direction, and only the nonuniform deposition in the downwind direction is indicated in the figure. Also contained in the figure is a set of layers whose total height approximates the nonuniform distribution. Figure 7 contains steady-state vapor concentrations from the nonuniform surface deposition of Fig. 6. Also contained in the figure are approximate values of the steady-state vapor concentrations obtained by adding the values from each of the layers in Fig. 6, where each layer represents a uniformly contaminated area with surface density equal to one-fourth of the peak value of the surface deposition of the nonuniformly contaminated area and the graphic method described in the previous subsection is used to determine the vapor concentration contributed by each layer.

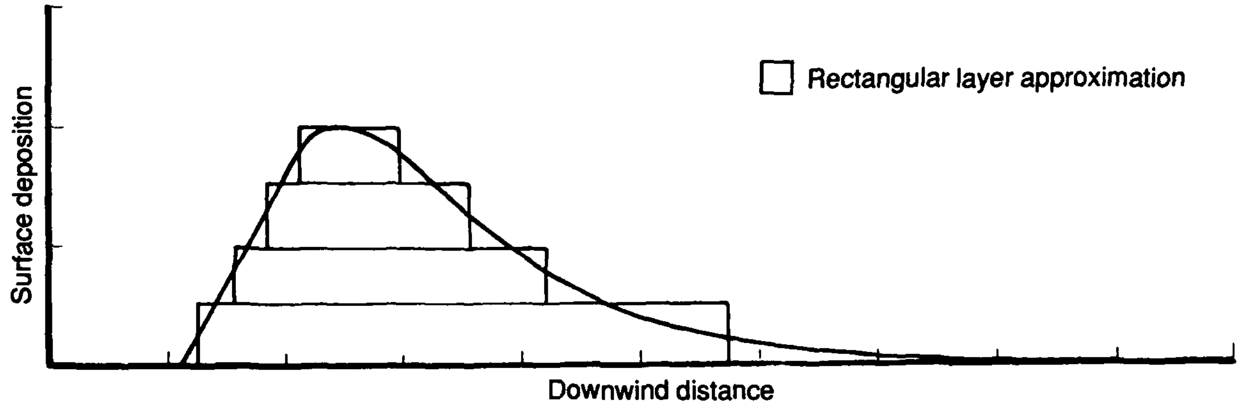

Fig. 6—Example of nonuniform agent surface deposition

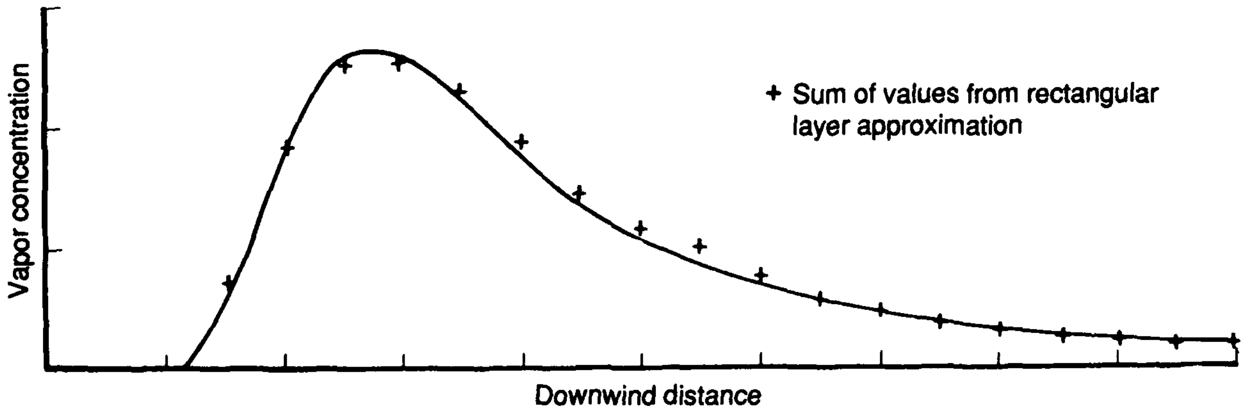

Fig. 7—Steady-state vapor concentration from the nonuniform agent surface deposition on Fig. 6

RESIDUAL AGENT SURFACE DEPOSITION AND VAPOR

As the liquid films evaporate into the airstream or become absorbed into the surface, the films become thinner and the total residual contamination in the films continually decreases. The evaporation rate is constant until the steady-state time T is reached and then continually decreases until the films are completely evaporated. From [20] the fraction remaining of the original surface deposition, R(t), at time t after the deposition is determined from

$$R(t) = 1 - (M1/(M0 + M1))((P0 + P1 + 2P)/(P1 + P))(t/T) \qquad 0<t<=T$$

$$= 1 - (M1/(M0 + M1))[(P0 + P1 + 2P)/(P1 + P) + ((P1 + P)/(1 - P0))$$

$$(B^2 (1/(C - t/T) - 1/(C - 1) + ((P + P0)/(P1 + P))^2 (1 - t/T))] \qquad T<t<=\tau$$

where

$$B = M0/M1 - (P0 + P1)(M1-M0)/(M1(P1 + P0))$$

and

$$C = (M1 - M0)(P1 + P)/(M1(P1 - P0))$$

Substituting T and τ from Eqs. (1) and (2), $M1/M0 = 10$, and $v = (M1/M0)(T/\tau)$ into R(t) results, after considerable algebraic reduction, in

$$R(t) = 1 - (1/11)(1 + v)t/T \qquad 0<t<=T$$

$$= v^2(\tau - t)^2/((T + v\tau)(t - T + v(\tau - t))) \qquad T<t<=\tau$$

$$= 1 - (1/11)((1 + v)t/T - (t/T - 1)^2/(9 + (1 - v)t/T))$$

$$= (100/11)(1 - t/\tau)^2/(t/T + 9 - 10t/\tau) \qquad (5)$$

The vapor concentration at any point over or downwind of the contaminated area after the steady-state period is decreased as the ratio of the current evaporation rate to the steady-state evaporation rate. Defining E(t) to be the evaporation rate at time t, we have (from [18]),

$$E(t)/E(T) = 1 \qquad 0 \leq t \leq T$$

$$= (P0/Pa)(L/L1) + (1 - P0/Pa)(L/L1)^2 \qquad (6)$$

$T \le t \le \tau$

where L/L1 (the fraction of the height of the grass from which the liquid films have completely evaporated) is equal to

$$L/L1 = (M0 - tCs(P0 + P))/(tCs(P1 - P0) - M1 + M0)$$

Substituting T, τ, and M1/M0 = 10 and simplifying results in

$$L/L1 = 1/(1 + 0.1(\tau/T)(t - T)/(\tau - t))$$

Figure 8 illustrates the change in surface deposition and vapor over time for values of T = 11 min and τ = 1268 min.

SURFACE DEPOSITION AND VAPOR FOR TSAR

TSARINA determines surface deposition densities at aircraft shelters, aircraft parking areas, and designated buildings by adding up the surface contamination densities for each rectangle of each chemical weapon that contains the location coordinates of those facilities. These are listed for each trial and, when specified, stored for use in TSAR in the TSAR Type 40 Card format.

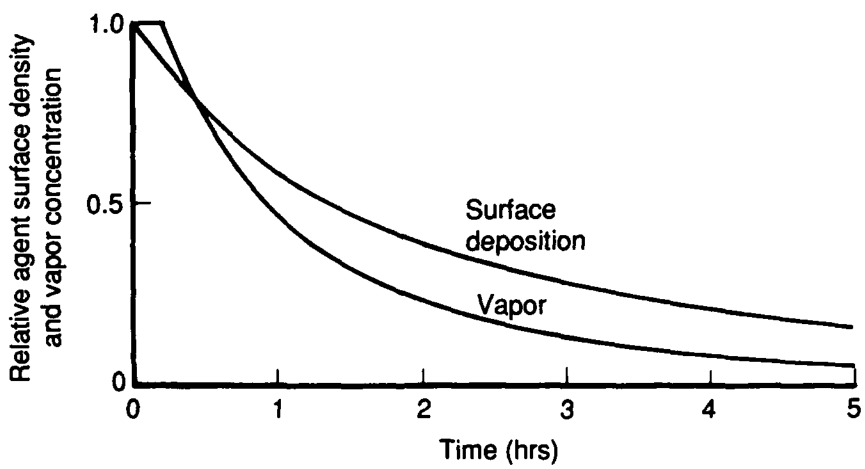

Fig. 8—Relative agent residual surface deposition density and vapor concentration for T = 11, τ = 1268 min

In addition, steady-state surface deposition densities and vapor concentrations and parameters for determining residual contamination densities and vapor concentrations over time are output for use in TSAR for each of up to 150 arbitrarily selected monitoring points on the airbase. For each half-rectangle of each weapon in each attack, and for each monitoring point at which vapor is produced by the half-rectangles, TSARINA outputs: (1) the steady-state values of surface contamination density and vapor concentration, (2) the arrival time of the surface deposition (the downwind distance of the monitoring point divided by the wind velocity), and (3) the values of T and τ for the half-rectangle (Eqs. (1) and (2)). TSAR uses these data to determine surface deposition densities and vapor concentrations at the monitoring points by adding up the contributions from each half-rectangle, using the steady-state surface deposition densities and the steady-state vapor concentrations and Eqs. (4) and (6) to determine the residual vapor concentrations.

TSARINA also outputs on #40 cards the closest monitoring point to each aircraft shelter, aircraft parking ramp, and designated building. TSAR uses the #40 card input of surface deposition densities at these facilities for the values at the time of the attack, but uses the residual surface deposition densities at the closest monitoring points for times after the attack and the vapor densities at the closest monitoring points at all times following the attack.

DISK OUTPUT OF RUNWAY HIT AND CHEMICAL ATTACK DATA

For TSAR simulations that evaluate the effects of repeated attacks on a system of airbases, the total number of hits on the runways of all the bases can be very large—when multiple simulation trials are made, the total number of runway hits that need to be output from TSARINA and input to TSAR can be in the thousands.

For chemical attacks, the chemical agent surface deposition pattern for each weapon is represented in TSARINA by as many as 17 subpatterns. TSARINA computes surface deposition densities on selected targets for each of the subpatterns and outputs the total densities (for up to three agent types) to TSAR by means of #40 cards. Additionally, TSARINA computes surface deposition densities and parameters for agent evaporation vapor densities for each subpattern at (up to) 150 locations (called monitoring points, or MPs) input by the user. The latter values (called chemical hit data) are output for use by TSAR for each subpattern and (affected) monitoring point.

To provide the runway crater data and the chemical "hit" data to TSAR in a straightforward manner, TSARINA places runway hit and chemical agent/MP data in an output file that is later processed by a separate program called ORDER, described in App. C. When field 7-12 of the DATA input card has a value of unity, TSARINA places the runway hit and chemical hit data (for the number of trials, specified in field 13-18) into separate output files—Trial #1 into FORTRAN dataset FT41F001, Trial #2 into FT42F001, etc.

Each TSARINA output file consists of six-byte logical records containing three data items written with a 3A2 format (with any user-defined physical record length that is a multiple of six bytes). Each data item is kept internally in integer*2 variables and the output files must be read into integer*2 variables with a 3A2 format. The following runway hit data are written into the output file of each trial for each base and runway.

1. Runway No., No. of hits, Base No.	(6 bytes)
2. Day, Hour, Minute (of attack)	(6 bytes)
3. LTH, WID, INL	(6 bytes)
4. INW, MCL, MCW	(6 bytes)
5. WDBAR, LABAR, LBBAR	(6 bytes)
6. RUNWT, BARWT, -----	(6 bytes)
7. X, Y coordinates, WR	
8. Repeat 7 for each hit	
9. Repeat 1 to 7 for each runway with hits	
10. 0, 0, 0 (End of data for the base)	(6 bytes)

The FORTRAN variables listed as items 3 through 6 are defined in App. B. In 7, X and Y are the down-runway and cross-runway coordinates of the hit *relative to the runway*, and WR is the crater radius of the hit.

Next, the chemical hit data are written into the output file for each trial and base.

1. −1, No. of MP's, Base No.	(6 bytes)
2. Day, Hour, Minute (of attack)	(6 bytes)
3. MP No., Agent No., Wind velocity	(6 bytes)
4. T1, T2, T3	(6 bytes)
5. Surfcd, Conc., 0	(6 bytes)
6. Repeat 3 to 5 for each MP affected	

by subpattern

7. 0, 0, 0 (End of data for subpattern) (6 bytes)
8. Repeat 1 to 7 for each subpattern
9. 0, 0, 0 (End of chemical hit data) (6 bytes)

T1, T2, and T3 are times in minutes after the attack. T1 is the arrival time of the vapor cloud from the subpattern at the MP, T2 is the steady-state time for the vapor cloud (the time to which the agent vapor concentration is constant), and T3 is the time at which the vapor concentration becomes zero. Surfcd is the surface deposition intensity (mg/sqm) at the MP, and Conc. is the steady-state vapor concentration (micrograms/cum) at the MP.

VI. SAMPLE PROBLEM

The layout of the test base is shown in Fig. 9. This base has a 150-ft × 6000-ft runway, a 50-ft × 6000-ft parallel taxiway, two aircraft parking ramps, and 24 aircraft shelters of three different types of construction organized into two squadron areas. Four of the shelters are oversized and are also designated for use as assembly areas for squadron maintenance personnel. Each squadron also has facilities for on-duty aircrews, weapons personnel and equipment, and collective protection. There are several intermediate maintenance shops, munitions storage and assembly areas, four barracks, and other facilities.[1]

INPUT

The input data that defines this base, and several attacks against the base, will be described in this subsection. The actual input card images are reproduced in the figures, and samples of the TSARINA output will also be illustrated.

The first three card images in Fig. 10 provide key control information for the TSARINA simulation. The control (CONT), data (DATA), and chemical warfare (CW) control cards should be entered first and in the order shown. Complete descriptions of the required entries are provided in App. A for all of the card types.

The CONT card specifies that the first 20 target types will be used, and that five trials are to be run for the simulation. The minimum clear length and width for the MOS are 2500 ft and 50 ft, respectively. The other entries are primarily used to control which results are to be listed in the output. The DATA card specifies that the results for the first five trials of the attack(s) are to be stored on disk for future use with the TSAR sortie generation model.

The DATA card also declares (to TSAR) that the first attack is against Base #1 at 0615 AM on day 1, and that target types #2, #16, and #17 are being used for three

[1] The problem used in this section to illustrate the input procedures and the appearance of TSARINA output is closely related to, but not identical with, the sample problem transmitted to new users along with the TSAR and TSARINA source codes. Furthermore, neither of these problems is identical with that used in the *TSAR Users' Manual* to illustrate that model.

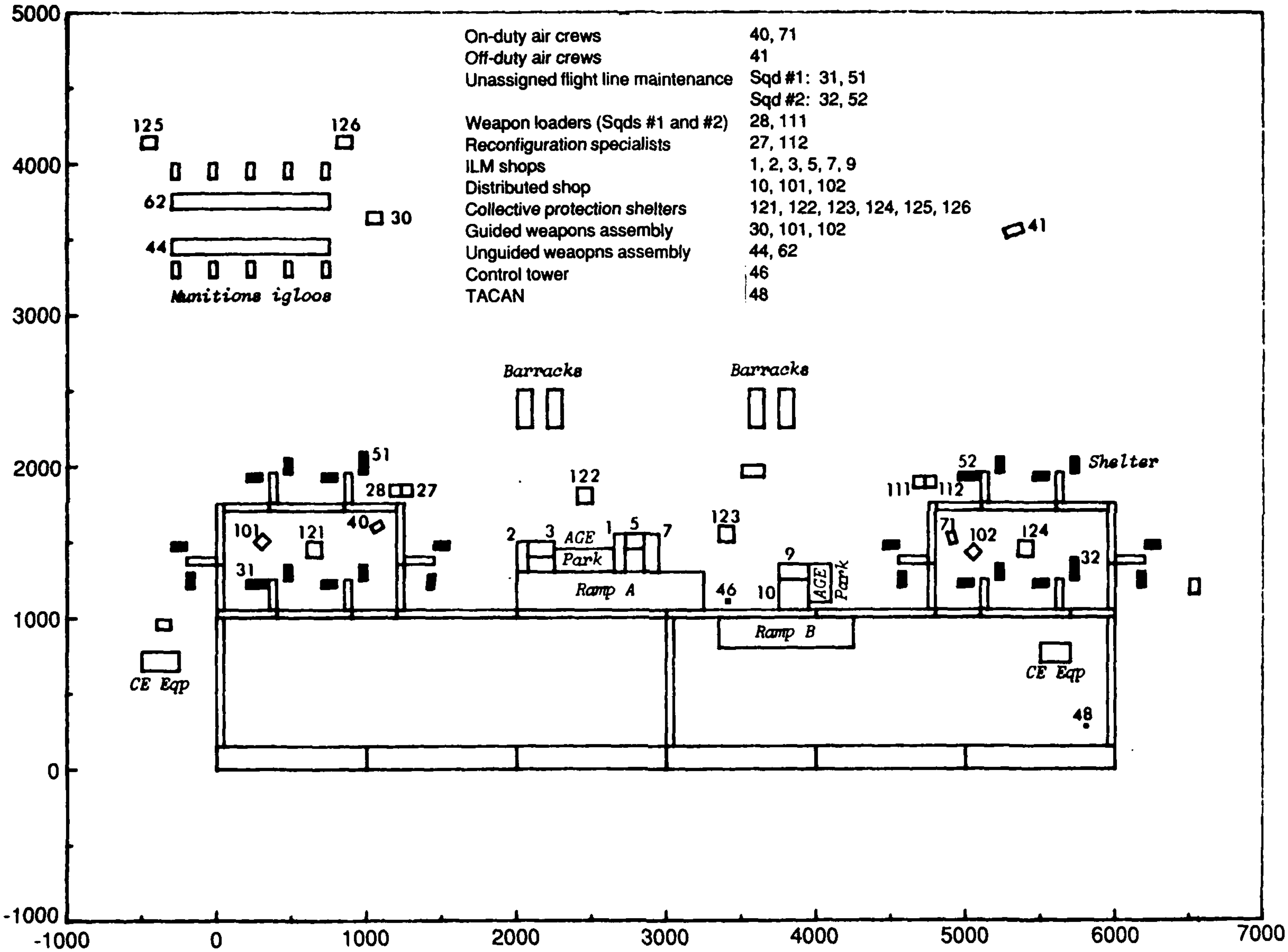

Fig. 9—Layout of test base

Model operations are specified with the CONTrol card.

```
CONT 1  1 20  5  0  1  4     0  2500     50  1  2     10    250
```

The DATA card controls key interactions with TSAR.

```
DATA 0     5           1     1   615      1  4  2 16 17 25  3     4
```

The CW card provides basic control data for using CW weapons.

```
CW         2    60    760    156     10     67     20     30   1002
```

In this example, 30 monitoring points are specified
on the CW card; their coordinates are entered here.

```
 500    75  1500    75  2500    75  3500    75  4500    75
5500    75    25   650  3025   650  5975   650  1600  1025
2600  1025  3850  1025  -100  1375   375  1850   875  1850
1350  1375   875  1150   375  1150   650  1450  2450  1550
3400  1550  4650  1375  5125  1850  5625  1850  6100  1375
5625  1150  5125  1150  5400  1450  3700  2400  2150  2400
```

The EQUIvalence data are used to assure compatability
of the resource types at the TSAR-TSARINA interface.

```
EQUI   20001     1   191   192   194
EQUI   20002     4    -1
EQUI   20002    10    96    97    99     0     0     0     0     0
EQUI   20002    16    16    17    18 20002    21    21    23     0
EQUI   20003     8 10002 20003   112 10003
EQUI   20004     2     1     2
EQUI   20004     3     3     4     5 20004   203   203   204   205
EQUI   20005     2     1     2 20005    -3     3     4     5
EQUI   20006     2     1     2     4     6     0     0     0     0
```

The PAD card defines the target type and size for
"pads" the model is to generate outside shelter doors.

```
PAD        20   100   100    19    50    50    18   100    50
```

The SKEW card directs that the search for an MOS
include consideration of locations skewed, as
well as parallel, with the runway.

```
SKEW       3
```

Fig. 10—TSARINA control data, monitoring points, equivalence data, "pad" directives, and MOS selection directives

different types of aircraft shelters, and that target types #3 and #4 designate taxiways and aircraft parking ramps, respectively.

The CW card specifies: that stability category 2 (for Pasquill stability category D) be used in the CW surface deposition evaporation calculations; that the temperature and atmospheric pressure at ground level are 60° and 760 Torrs; that the predicted wind direction is 150° from the north with an uncertainty of ± 10°. The predicted surface wind velocity is 6.7 mph with a 20 percent uncertainty, or ± 1.3 mph; 30 monitoring points are to be used; the transport velocity to the surface material of the first chemical agent is 10 cm/min, and the TSARINA agent number for the first chemical agent is 2 (for agent GD). The coordinates of the monitoring points must be entered on supplementary cards immediately following the CW cards. Six cards are needed for the 30 monitoring points.

The several EQUIvalence cards are used to translate various resource type designations used in this TSARINA data base into their equivalent type designators in a companion TSAR data base. The first EQUI card declares that the loss rate estimated in TSARINA for personnel type #1 should be applied in TSAR to personnel types #191, #192, and #194. The second EQUI card specifies that the loss rate estimated in TSARINA for equipment type #4 should not be transferred to TSAR. The third EQUI card indicates that the data estimated in TSARINA for equipment #10 should be applied to equipments #96, #97, and #99 in TSAR. The fifth EQUI card specifies that the loss rate estimated in TSARINA for parts #8 and #112 should be applied in TSAR to the two sets of parts #8, #9, and #10 and #112, #113, #114, and #115, respectively; this special feature for referring to a set of consecutively numbered types may only be used with spare parts.

The PAD card specifies that a TGT card is to be prepared to represent a 100 ft × 100 ft wide pad in front of each Type #1 aircraft shelter door for the purposes of reflecting the enhanced effectiveness of weapons that drop in front of the door; the target type for these pads is #20. Pads for the second and third types of aircraft shelters are to be 50 ft × 100 ft wide and 100 ft × 50 ft wide, respectively, and are to be designated target types #19 and #18.

The SKEW card specifies that when runways are examined for the availability of an MOS, that locations that are skewed, as well as parallel, to the sides of the runway are to be considered. The "3" in column 12 indicates that the program should use an angular step size of 3/4° between the locations that are examined.

The first group of target (TGT) cards is shown in Fig. 11. Each target is defined by its westernmost corner, its size, orientation,[2] and target type. The TSAR facility number is also entered for those "buildings" when the damage to the facility and the estimated loss rates for personnel, equipment, and spare parts are to be transferred to TSAR; in this example the facility numbers have been entered for the several shop

```
        The first set of target cards are listed below; they
        include the flight surfaces, aircraft parking ramps,
        shops, rest facilities, and other support facilities.

TGT        0     0   150  6000     0     1                              RUNWAY
TGT        0  1000    50  6000     0     1                              MAIN TAXIWAY

TGT     2000  1050   250  1250     0     4                              RAMP A
TGT     3350   800   200   900     0     4                              RAMP B
TGT     2650  1300   250    75     0     5           1                  SHOP #1
TGT     2000  1300   200    75     0     5           2                  SHOP #2
TGT     2075  1400   100   175     0     5           3               1  SHOP #3
      C  1  101   10
TGT     2725  1450   100   125     0     5           5                  SHOP #5
TGT     2850  1300   250   100     0     5           7                  SHOP #7
TGT     3750  1250   100   200     0     5           9                  SHOP #9
TGT     3750  1050   200   200     0     7          10               2  SHOP #10
      C  2   16  100 C  3    3   25 C  3    8   20 C  3   12   40
      C  3  112   30 C  1  101   10
TGT      250  1500    75    75    45     7         101               1  SHOP #10A
      C  3    3   10 C  1  101   20
TGT     5000  1425    75    75    45     7         102               1  SHOP #10B
      C  3    3   10 C  1  101   20
TGT     3500  1925    75   150     0     5                           2  WAREHAUS
      C  3    3   55 C  3   12   60 C  3  112   70 C  3    8   80
      C  3    0  100

TGT     1150  1800    75    75     0     5          28                  AMMO SHOP1
TGT     4650  1850    75    75     0     7         111                  AMMO SHOP2
TGT     1225  1800    75    75     0     5          27                  RCFG #1
TGT     4725  1850    75    75     0     7         112                  RCFG #2
TGT     2250  1300   150   400     0    12                           1  VEHICLE PARK#1
      C  2    2   30 C  2    3   25 C  2    4   60
TGT     3950  1100   250   150     0    12                           1  VEHICLE PARK#2
      C  2    2   50 C  2    3   50 C  2    4   40

TGT     3400  1100    20    20     0     5          46                  TOWER
TGT     5800   275    10    10     0     5          48                  APPROACH
TGT     1025  1600    75    50    60    10          40                  CREW #1
TGT     4875  1550    50    75    75    10          71                  CREW #2
TGT     5250  3550   125    60    70    11          41                  CREW REST
TGT     2000  2250   250   100     0    15                           1  BARRACK #1
      C  1 1000   20 C  1 1003   44
TGT     2200  2250   250   100     0    15                           1  BARRACK #2
      C  1 1000   20 C  1 1003   22
TGT     3550  2250   250   100     0    15                           1  BARRACK #3
      C  1 1000   20 C  1 1003   34
TGT     3750  2250   250   100     0    15                           1  BARRACK #4
      C  1 1000   40
```

Fig. 11—TSARINA target data for runways, shops, barracks, and other facilities

---

[2]An auxiliary program is available for converting dimension data prepared for the MASSIVE program (developed at Eglin AFB) into the format required for TSARINA.

buildings, as well as for various other buildings. The resources located at the various targets are specified on supplementary cards that immediately follow the appropriate target; these cards are easily identified by the "C"s, which are followed by the class number, type number, and percentage.

```
        The second set of targets include the collective
        protection buildings, civil engineering personnel
        and equipment holding areas, and the munitions-
        related facilities.

TGT       600  1400   100   100     0     8          121              1  CPS #1
        C  1  101   10
TGT      2400  1750   100   100     0     8          122              1  CPS #2
        C  1  101   10
TGT      3350  1500   100   100     0     8          123              1  CPS #3
        C  1  101   10
TGT      5350  1400   100   100     0     8          124              1  CPS #4
        C  1  101   10

TGT      -400   925    65    95     0     5                           1  CE WAIT1
        C  1    1   50
TGT      6500  1150    95    65     0     5                           1  CE WAIT2
        C  1    1   50
TGT      -500   650   125   250     0    13                           1  CE PARK1
        C  2   10   60 C  6     2    50 C  2    3    25
TGT      5500   700   125   200     0    13                           1  CE PARK2
        C  2   10   40 C  6     2    50

TGT      1000  3600    75   100     0     5           30                 MAIN AMMO
TGT      -300  3400   100  1050     0    14           44              1  AMMO AREA1
        C  2   21   50
TGT      -300  3700   100  1050     0    14           62              1  AMMO AREA2
        C  2   21   50

TGT      -500  4100    75   100     0     8          125                 AMMO CPS
TGT       800  4100    75   100     0     8          126                 AMMO CPS
TGT      -300  3250   100    50     0     9                           1  IGLOO #1
        C  4  202   10 C  4   203    40 C  4    0    10 C  5   2   15
TGT       -50  3250   100    50     0     9                           1  IGLOO #2
        C  4  202   30 C  4   203    20 C  4    0    10
TGT       200  3250   100    50     0     9                           1  IGLOO #3
        C  4  202   20 C  4   203    10 C  4   .0    20 C  5   3   15
TGT       450  3250   100    50     0     9 .                         1  IGLOO #4
        C  4  202   20 C  4     0    20 C  5    2    23
TGT       700  3250   100    50     0     9                           1  IGLOO #5
        C  4  202   20 C  4   203    10 C  4   11    50 C  5   2   12
TGT      -300  3900   100    50     0     9                           1  IGLOO #6
        C  4  203   10 C  4    11    50 C  5    3    15
TGT       -50  3900   100    50     0     9                           1  IGLOO #7
        C  4   12   20 C  4     0    10 C  4   41    50 C  5   3   10
TGT       200  3900   100    50     0     9                           1  IGLOO #8
        C  4   12   20 C  4     0    10 C  4   41    50 C  4  42   50
TGT       450  3900   100    50     0     9                           1  IGLOO #9
        C  4   12   20 C  4     0    10 C  4   43    50 C  4  42   50
TGT       700  3900   100    50     0     9                           1  IGLOO #10
        C  4   12   20 C  4   203    10 C  4    0    10 C  4  43   50
```

Fig. 12—TSARINA target data for support facilities

The runway and main taxiway, the shops, squadron munitions facilities, aircrew facilities, and barracks are shown in Fig. 11; the collective-protection facilities, civil engineering holding areas for personnel and equipment, and the munitions storage and assembly facilities are shown in Fig. 12. As can be noted, the location of some munitions types (#4, #11, #12, #202, and #203) are specified for the individual types, whereas the rest are indicated as munition type #0, which refers to "all other" types. (Since NOMUN was 200 in the TSARINA source code for this sample problem, munitions type #202 and #203 refer to unassembled type #2 and #3 munitions, i.e., TYPE + NOMUN.)

Samples of the target cards for the three types of aircraft shelters and for the taxiways are shown in Fig. 13. The TGT cards are duplicated for the four oversized shelters, since they are to be used both to shelter aircraft and to act as assembly points for unassigned squadron maintenance personnel. The appearance of two identically located facilities causes no problem, and permits one to be identified as a shelter and the other as the squadron assembly area (using a different target type). Naturally, the vulnerability data entered on the EMD card should correspond for the two target types, unless one wishes to employ the flexibility of the EMD cards to specify different levels of vulnerability for different categories of resources in the structure. The numbers entered in column 32 of the aircraft shelter TGT cards designate the location of the shelter door. As specified by the PAD card a special 100 ft × 100 ft target is created in front of each Type #1 shelter door to permit the increased vulnerability to impacts in front of the shelters to be represented; pads of different sizes are created in front of the Type #16 and #17 shelters.

The taxiway target cards are to be entered in the same order in which they are numbered in the TSAR data base; also taxiway segments that are coincident with a runway must have the number of the runway entered in column 54, as illustrated for the first nine taxiway segments in the sample.

Figures 14, 15, and 16 reproduce the weapon descriptions entered with the UXO and EMD cards. The UXO cards designate the range of fuze-delay settings for those Type #1 and #2 weapons that are reliable but are not to detonate on impact; the Type #1 UXOs will detonate between one and four hours (20 to 80 TTU)[3] after impact. These cards also designate the percentages of the personnel and equipment that are lost when they are working at or near the UXOs at the time that they explode. The reader is

[3] TSAR time units—three-minute time intervals.

Samples from the aircraft shelter data cards are listed next. Four extra-length shelters are duplicated so as to also be the locations where ground maintenance personnel await assignment. It is mandatory that the target cards for the aircraft shelters be entered in exactly the same order that the shelters are numbered in the TSARINA and TSAR data bases.

```
TGT    -200  1200   100    50 2   0     2                          1  SHELTER #1
     C  4     2    20 C  4    3   20
TGT    -300  1450    50   100 3   0     2                             SHELTER #2
TGT     200  1900    50   100 3   0     2                          1  SHELTER #3
     C  4    12     2 C  5    2   .4
TGT     450  1950   100    50 4   0     2                             SHELTER #4
TGT     700  1900    50   100 3   0     2                          1  SHELTER #5
     C  4    12     2 C  5    3   10
TGT     950  1950   140    50 4   0     2                          1  SHELTER #6
     C  4     2    20 C  4    3   20
TGT     950  1950   140    50     0     6        51                   SQD #1 ALT

TGT     200  1200    50   140 3   0     2                          1  SHELTER#12
     C  4     2    20 C  4    3   20
TGT     200  1200    50   140     0     6        31                   SQD #1
TGT    4550  1200   100    50 2   0    17                          1  SHELTER#13
     C  4    12     2 C  2    2    5
TGT    4450  1450    50   100 3   0    17                          1  SHELTER#14
     C  5     2   8.3
TGT    4950  1900    50   140 3   0    17                          1  SHELTER#15
     C  4    12     2 C  5    3   10
TGT    4950  1900    50   140     0     6        52                   SQD #2 ALT
TGT    5200  1950   100    50 4   0    17                          1  SHELTER#16
     C  4     2    20 C  4    3   20
TGT    5450  1900    50   100 3   0     2                          1  SHELTER#17
     C  4    12     2
TGT    5700  1950   100    50 4   0     2                             SHELTER#18

TGT    5200  1250   100    50 4   0     2                          1  SHELTER#23
     C  5     2   8.3 C  5    3 13.4
TGT    4950  1200    50   100 3   0     2                             SHELTER#24
```

The last of the target cards listed for the sample problem are the cards that describe the taxiway network; only a sample of these cards is shown here. It is mandatory that these target cards be entered in exactly the same order that the taxiway segments are numbered in TSARINA and TSAR.

```
TGT       0     0   150  1000     0     3        1          TXWY# 1
TGT    1000     0   150  1000     0     3        1          TXWY# 2
TGT    2000     0   150  1000     0     3        1          TXWY# 3
TGT    3000     0   150  1000     0     3        1          TXWY# 4
TGT    4000     0   150  1000     0     3        1          TXWY# 5
TGT    5000     0   150  1000     0     3        1          TXWY# 6
TGT       0  1000    50   400     0     3        2          TXWY# 7
TGT     400  1000    50   500     0     3        2          TXWY# 8
TGT     900  1000    50   300     0     3        2          TXWY# 9
TGT    6000  1350    50   200     0     3                   TXWY#42
TGT    5950  1050   300    50     0     3                   TXWY#43
TGT    5600  1050   200    50     0     3                   TXWY#44
TGT    5100  1050   200    50     0     3                   TXWY#45
```

Fig. 13—TSARINA target data for shelters and taxiways

The UXO cards define the range of delay times before the unexploded ordnance is to explode in the TSAR simulation, and the expected casualties to personnel and equipment.

```
UXO        1    20    80    50    50    75    25    10    10
UXO        2    40   100    25    20    50    15    10    10
```

The EMD cards are used to enter weapon effectiveness data for the various weapon types. The formats differ somewhat for point-impact weapons, dispenser weapons, and chemical weapons. And each EMD card is normally associated with several supplementary cards that must follow the EMD card.

The first weapons data are for hypothetical general purpose bomb.

```
EMD 16  1 95    20     2     20     20    100      2     20    120      4      5
      20 250          150    40     4C    140    150     40     35    100     40
   PERSONNEL           75120 80120 80     75     75     75 80 80          90 95
   EQUIPMENT           55 90 75 90 75     15     55     15
   PARTS               35120100120100     24     35     26
   AMMO                40 80 80 80 80     17     40                  80
   TRAP                45                 29     45
   MATERIAL
   FLAG            33333 7776  7776  12312033333 222     7          3  8
                      100

   PERSONNEL           55
   EQUIPMENT           68
   PARTS               33
   AMMO                40
   TRAP                12
```

A second set of cards must be entered for target types larger than #10; these cards are identical in number and format to those for the first 10 target types, except the first 12 columns of the first and second cards are to be left blank.

```
                60     20     20     30    120     10     30     75    100     50
                       40     40     40     35    150    150     70     90     80
   PERSONNEL    65120 80120 80120 80 80 90     90     50     70     90     80
   EQUIPMENT       90 75 80100 70 90           75     35     70     90     80
   PARTS                                       50     25     90     95     50
   AMMO                             50         50     25     80     70     90
   TRAP                                        50     25     20     50     45
   MATERIAL               60100                              40     25     30
   FLAG      1     77     76    676 6  7     33333 33333 121212121212121212
                80                             75     50
                                        50
   PERSONNEL    80                   100100    60     40
   EQUIPMENT                                   50     35
   PARTS                                       40     30
   AMMO                                        30     25
   TRAP                                        20     20
```

Fig. 14—Weapon effectiveness for a GP bomb

referred to the appropriate parts of App. A for a full explanation of the UXO card and the various EMD data.

Figure 17 presents the attack information for four attacks. Each attack (ATT) card identifies the attack heading and any uncertainty to be associated with that heading, the intended aim point, the aiming accuracy, and the ballistic dispersion of the weapons; the number of weapons, the stick length, and arrival probability are also specified. For CW weapons the height of burst must also be entered; and when target height has been specified for any target types the weapon impact angle (relative to vertical) should be entered. The first attack against Base #1 at 0615 on day 1 uses eight tactical ballistic

```
     The second weapon type is a TBM delivering a pattern of 40
     BKEPs.  As can be noted, this submunition is represented as
     ineffective against aircraft shelters (target type #9) and
     its equivalent, the squadron maintenance assembly areas.

EMD  9  2 95     5     0     5     5    15     0    10    10     0    10TBM/BKEP
       15 100                10    10    30          15    20          20
   PERSONNEL              40 50 40 80    50          40    60          40
   EQUIPMENT              20 50 25 80    30          25
   PARTS                  30100 30100    25          20
   AMMO                   20100 20100    30
   TRAP                                  30
   MATERIAL
   FLAG                 7676  7776  33311      333   3            3
                 15    5     5     5    15
                      10    10    10
   PERSONNEL 30 50 40 80 40 80 40 30 30 30
   EQUIPMENT       25 80 20 50 20 50
   PARTS
   AMMO                        20 90
   TRAP
   MATERIAL                 80
   FLAG      6     77    76   376 6  6

     The characteristics of the submunitions in the pattern are
     specified with the PATT card and supplementary cards that
     specify the downrange and crossrange aim points for the
     40 individually targeted submunitions.

PATT         1    40     2   950                                                TBM/BKEP
  250   247   238   223   202   177   147   113    77    39     0   -39   -77  -113  -147  -177
    0    39    77   113   147   177   202   223   238   247   250   247   238   223   202   177
 -202  -223  -238  -247  -250  -247  -238  -223  -202  -177  -147  -113   -77   -39     0    39
  147   113    77    39     0   -39   -77  -113  -147  -177  -202  -223  -238  -247  -250  -247
   77   113   147   177   202   223   238   247
 -238  -223  -202  -177  -147  -113   -77   -39
```

Fig. 15—Effectiveness data for a hypothetical BKEP warhead

missiles (TBMs) with BKEP to pin aircraft in; that attack is followed at 0718 by 12 aircraft targeted against the runway/taxiway at 0718, four targeted against aircraft shelters, and three delivering chemical bombs. The third attack on Base #1 at 1215 assigns three fighter-bombers against the MOS, and additional aircraft are assigned to attack other targets. The –1 in columns 63/64 of the first ATT card for the third attack designates that during the TSAR simulation three aircraft are to be presumed to be targeted against the MOS selected in TSAR after the prior attack. The fourth attack is against Base #2. The nature of these several attacks differ substantially as noted by the comments in Fig. 17.

```
    The third weapon type is an aircraft dispenser with bomblets
    and 250 mines.  The second card for the first 10 target types
    is blank, and the rates for casualties, equipment damage,
    aircraft damage, and aircraft kill are entered on the next
    four cards for taxiways and ramps.  Personnel and equipment
    loss rates are given for some of the last 5 target types;
    only the four loss rate cards are required for these target types.

EMD  6   3 95 -1000   300    250     30

   PERSONNEL                  45      45      5
   EQUIPMENT                  25      25
   PARTS                      35      35
   AMMO                       20      20
   PERSONNEL          45      45      45     10
   EQUIPMENT          25      10      10
   PARTS
   AMMO                                5

   The fourth weapon type is a TBM with a chemical warhead.
   The chemical deposition is approximated with three layers
   each with a constant density; the mean mass diameter is
   given for the upwind half and downwind half of each rectangle.

EMD  3   4100     -1   6977   2906   2319     0     67     53   2500   1000   2320 TBM/CW
                       3779   1889   2473     0     67    350   3300   1400   2320
                       1775    872   2932     0     67   1287   3600   2200   2320

   The fifth weapon type is an aircraft delivered chemical dispenser.
   The deposition for this weapon is also represented by three
   rectangles, as for weapon type #4, but the individual areas
   are much smaller.

EMD  3   5100     -1   1840    490    360     0     67     24   3700    800   2320 AC/CW
                       1020    380    395     0     67    287   4000   1500   2320
                        525    230    440     0     67   2582   5000   3000   2320
```

Fig. 16—Effectiveness data for a dispenser with mines and CW weapons

The first attack is against Base #1 and targets 8 TBMs with BKEP warheads against the main runway and main taxiway.

```
                                                                     BASE#1
ATT  2   0 0  2000    75   200   300   25   30   1   0   2   80
ATT  2   0 0  4000    75   200   300   25   30   1   0   2   80
ATT  2   0 0  2000  1025   200   300   25   30   1   0   2   80
ATT  2   0 0  4000  1025   200   300   25   30   1   0   2   80
REDO            -1     1     1
```

The second attack at Base #1 uses three fighter-bomber aircraft each delivering six chemical cannisters, twelve aircraft dropping bombs on the runway and taxiway, two aircraft dropping mines on those surfaces, and four aircraft attacking aircraft shelters.

```
DATA 0    3          1     1   718     1  4  2  16 17 25  3     4        BASE#1:
CW        2    60  760   168    10    67     20    -30  1002
ATT  1  20 5   700  1600   150    75    75    35     6  2000   98 5    90
ATT  1  20 5  2800  1600   150    75    75    35     6  2000   98 5    90
ATT  1  20 5  4900  1600   150    75    75    35     6  2000   98 5    90
ATT  4  75 5  2000    75   150    45    60    53    10   800      1    95
ATT  4  75 5  4000    75   150    45    60    53    10   800      1    95
ATT  2  75 5  2000  1025   150    45    60    53    10   800      1    95
ATT  2  75 5  4000  1025   150    45    60    53    10   800      1    95
ATT  1  90 2  3000    75   150    75   100    65     5  5000      3    90
ATT  1  90 2  9000  1025   150    75   100    65     5  5000      3    90
ATT  1  9010   800  1200   150    45    60    53    10   800      1    95
ATT  1  9010  5500  1200   150    45    60    53    10   800      1    95
ATT  1  9010   800  1800   150    45    60    53    10   800      1    95
ATT  1  9010  5400  1800   150    45    60    53    10   800      1    95
REDO            -1     1     1
```

The third attack at 1215 is also against Base #1; the first three aircraft are directed to drop their bombs at the mid-point of the MOS selected after the first two attacks. In addition four TBMs are targeted on the flight surfaces, two aircraft drop mines on those surfaces, and eight aircraft attack the aircraft shelters.

```
DATA 0    3          1     1  1215     1  4  2  16 17 25  3     4        BASE#1
ATT  3  75 5 20000 20000   150    45    60    53    10   800   -1 1    95
ATT  1   0 0  2000    75   200   300    25    30     1     0      2    80
ATT  1   0 0  4000    75   200   300    25    30     1     0      2    80
ATT  1   0 0  2000  1025   200   300    25    30     1     0      2    80
ATT  1   0 0  4000  1025   200   300    25    30     1     0      2    80
ATT  1  90 2  3000    75   150    75   100    65     5  5000      3    90
ATT  1  90 2  9000  1025   150    75   100    65     5  5000      3    90
ATT  2  9010  2200  1300   150    45    60    53    10   800      1    95
ATT  2  9010  4000  1150   150    75    60    53    10   800      1    95
ATT  1  9010   800  1200   150    45    60    53    10   800      1    95
ATT  1  9010  5500  1200   150    45    60    53    10   800      1    95
ATT  1  9010   800  1800   150    45    60    53    10   800      1    95
ATT  1  9010  5400  1800   150    45    60    53    10   800      1    95
REDO            -1     1     1
```

The fourth attack is the first attack against Base#2 and is scheduled for 0606 on day 1; four TBMs deliver chemical warheads and four TBMs attack the flight surfaces.

```
DATA 0    3          2     1   606     1  4  2  16 17 25  3     4        BASE#2:
CW        2    60  760   147    10    67     20    -30  1002
ATT  1 270 0   -75  5000   200   300    25    30     1     0 492 4    80
ATT  1 270 0  1200  5000   200   300    25    30     1     0 492 4    80
ATT  1 270 0  2475  5000   200   300    25    30     1     0 492 4    80
ATT  1 270 0  3750  5000   200   300    25    30     1     0 492 4    80
ATT  1   0 0  2000    75   200   300    25    30     1     0      2    80
ATT  1   0 0  4000    75   200   300    25    30     1     0      2    80
ATT  1   0 0  2000  1025   200   300    25    30     1     0      2    80
ATT  1   0 0  4000  1025   200   300    25    30     1     0      2    80
END
```

Fig. 17—TSARINA input data for four attacks

It should be noted that the ATT cards for each attack are terminated either with a REDO card or an END card. The REDO card calls for entry of new sets of TGT and/or ATT cards, whereas the END card terminates the TSARINA run. Each set of ATT cards has been accompanied by a DATA card and a CW card, since some of the attack characteristics specified with those cards (base, time, wind) were to be changed. Note that all of the pertinent information must be indicated on these cards, not just those items whose value is being changed.

OUTPUT

The initial TSARINA output provides a record of the input data. The first of these data, illustrated in Fig. 18, provides a record of all the resource equivalence data that have been entered. This is followed by a list of all resource-packet data, including the number, name, and location of the target at which the resources are stored. Data defining whatever controlled submunition patterns have been entered are then listed, along with a summary of the space that has been used in the EQUIV and STOCKS arrays. The formatted title block shown in Fig. 19 is listed next; it indicates the values for several of the key control parameters. The identification number of the run, the scheduled time of the attack, the clear width requirement for taxiing, and an indication of any coordinate translation that was required are indicated next. These are followed by full particulars on the targets. To distinguish aircraft shelters from other numbered facilities, TSARINA adds a "1000" to each shelter number to avoid ambiguity; a "2000" or "3000" is added to the number of each taxiway and ramp for the same reason. The "pads" that may be created in front of aircraft shelter doors are designated by adding "4000" to the shelter number, as can be noted by examining target types #17 and #18. The location of the chemical monitoring points, the characteristics of the attacks, and the meteorological data are shown in Fig. 20. The weapon effectiveness data shown in Fig. 21 conclude the input data record.

TSARINA output for each trial is illustrated in Fig. 22, using some of the results for the second trial. As will be noted, both the runway and the main taxiway were hit; of the 50 bombs that affected the runway, 10 did not hit the runway itself but hit close enough for the runway to be within the bomb's 20-foot radius of effectiveness. One of the aircraft shelters shown received a hit, and chemical agents fell on six.

```
                    RESOURCE EQUIVALENCE CARD IMAGES

EQUI                20001      1     191     192     194       0       0       0       0       0       0
EQUI                20002      4      -1       0       0       0       0       0       0       0       0
EQUI                20002     10      96      97      99       0       0       0       0       0       0
EQUI                20002     16      16      17      18   20002      21      21      23       0       0
EQUI                20003      8   10002   20003     112   10003       0       0       0       0       0
EQUI                20004      2       1       2       0       0       0       0       0       0       0
EQUI                20004      3       3       4       5   20004     203     203     204     205       0
EQUI                20005      2       1       2   20005       3       3       4       5       0       0
EQUI                20006      2       1       2       4       6       0       0       0       0       0


          RESOURCE STORAGE DATA
TARGET NUMBER      NAME
       7           SHOP #3     2075    1400
                            C  1  101   100       C
      11           SHOP #10    3750    1050
                            C  2   16  1000       C  3    3  250       C  3    8  200       C  3   12  400       C
                            C  3  112   300       C  1  101  100       C
      12           SHOP #10     250    1500
                            C  3    3   100       C  1  101  200       C
      13           SHOP #10    5000    1425
                            C  3    3   100       C  1  101  200       C
      14           WAREHAUS    3500    1925
                            C  3    3   550       C  3   12  600       C  3  112  700       C  3    8  800       C
                            C  3    0  1000       C
      19           VEHICLE     2250    1300
                            C  2    2   300       C  2    3  250       C  2    4  600       C
      20           VEHICLE     3950    1100
                            C  2    2   500       C  2    3  500       C  2    4  400       C
      26           BARRACK     2000    2250
                            C  1 1000   200       C  1 1003  440       C
      27           BARRACK     2200    2250
                            C  1 1000   200       C  1 1003  220       C
      28           BARRACK     3550    2250
                            C  1 1000   200       C  1 1003  340       C
      29           BARRACK     3750    2250
                            C  1 1000   400       C
      30           CPS #1       600    1400
                            C  1  101   100       C
      31           CPS #2      2400    1750
                            C  1  101   100       C

      46           IGLOO #4     450    3250
                            C  4  202   200       C  4    0  200       C  5    2  230       C
      47           IGLOO #5     700    3250
                            C  4  202   200       C  4  203  100       C  4   11  500       C  5    2  120       C
      48           IGLOO #6    -300    3900
                            C  4  203   100       C  4   11  500       C  5    3  150       C
      49           IGLOO #7     -50    3900
                            C  4   12   200       C  4    0  100       C  4   41  500       C  5    3  100       C

      53           SHELTER     -200    1200
                            C  4    2   200       C  4    3  200       C
      57           SHELTER      200    1900
                            C  4   12    20       C  5    2    4       C
      61           SHELTER      700    1900
                            C  4   12    20       C  5    3  100       C
      63           SHELTER      950    1950
                            C  4    2   200       C  4    3  200       C
      66           SHELTER     1450    1450
                            C  4   12    20       C  2    2  100       C
      68           SHELTER     1400    1200
                            C  4   12    20       C
      70           SHELTER      950    1250
                            C  4    2   200       C  4    3  200       C
      72           SHELTER#     700    1200
                            C  4   12    20       C


   PATTERN TYPE # 1 IS DELIVERED BY WPN TYPE  2 AND HAS  40 SUBMUNITIONS; INDIVIDUAL RELIABILITY IS  950

                  250   247   238   223     202   177   147   113      77    39     0   -39     -77  -113  -147  -177
                    0    39    77   113     147   177   202   223     238   247   250   247     238   223   202   177

                 -202  -223  -238  -247    -250  -247  -238  -223    -202  -177  -147  -113     -77   -39     0    39
                  147   113    77    39       0   -39   -77  -113    -147  -177  -202  -223    -238  -247  -250  -247

                   77   113   147   177     202   223   238   247       0     0     0     0       0     0     0     0
                 -238  -223  -202  -177    -147  -113   -77   -39       0     0     0     0       0     0     0     0

STORAGE OF THE RESOURCE LOCATIONS REQUIRED  166 LOCATIONS IN THE STOCKS ARRAY,
AND THE EQUIVALENCE DATA USED   45 ELEMENTS OF THE EQUIV ARRAY.

                                                                        FIRST RANDOM NUMBER:      0.284217
```

Fig. 18—TSARINA record of selected input data

```
******************************************************************************************************************************
          ***   TSARINA   ***   A MODEL TO ASSESS CONVENTIONAL AND CHEMICAL ATTACKS FOR THE TSAR SIMULATION
                          DEVELOPED AT THE RAND CORPORATION BY D.E. EMERSON AND L.H. WEGNER
                                     BASED ON THE AIDA MODEL OF AIRBASE DAMAGE ASSESSMENT
******************************************************************************************************************************
NO OF TRIALS   5 NPRINT  1  DAMAGE  4  MODE  1  MCL   2500( 250)   MCW   50(10)   THETA  0.75  MIN REPAIR 1  PLOT HITS 2   TEST  0
******************************************************************************************************************************
                                                                                            AUGUST  1, 1989     11:49 AM
                                                 CASE #  1

                    IN THE TSAR SIMULATION, THIS ATTACK AND DAMAGE OCCUR AT BASE # 1 ON DAY  1 AT  7:18

                                   *****  BASE COMPLEX NAME - DEMO        *****

                        ********************  IDENTIFICATION NUMBER #  3056   ********************

                         THE MAXIMUM "MOS" SKEW ANGLE PERMITTED IS 25 DEGREES

                         TAXIWAY REPAIRS ARE BASED ON A CLEAR WIDTH REQUIREMENT OF 25 FEET

                         DATA WERE ENTERED FOR  149 TARGETS AND  21 ATTACKS.

                         PADS ARE PLACED IN FRONT OF THE AIRCRAFT SHELTERS
                         SHELT TYPE      PAD TYPE      PAD LENGTH    PAD WIDTH
                              1             20             100          100
                              2             19              50           50
                              3             18             100           50
```

TARGET DATA

NUMBER	X-DIM	Y-DIM	NE LIMB	SE LIMB	ANGLE	TGT TYPE	STORE	BLDG NO	

ALL TARGET LOCATION DIMENSIONS WERE INCREASED BY 1000 IN THE X-DIMENSION AND 0 IN THE Y-DIMENSION

NUMBER	X-DIM	Y-DIM	NE LIMB	SE LIMB	ANGLE	TGT TYPE	STORE	BLDG NO	
			** TARGET TYPE # 1 **						
1	1000	0	150	6000	0	1	0	0	RUNWAY
2	1000	1000	50	6000	0	1	0	0	MAIN TAX
			** TARGET TYPE # 2 **						
53	800	1200	100	50	0	2	0	1001	SHELTER
55	700	1450	50	100	0	2	0	1002	SHELTER
57	1200	1900	50	100	0	2	0	1003	SHELTER
59	1450	1950	100	50	0	2	0	1004	SHELTER
61	1700	1900	50	100	0	2	0	1005	SHELTER
63	1950	1950	140	50	0	2	0	1006	SHELTER
66	2450	1450	50	100	0	2	0	1007	SHELTER
74	1450	1250	100	50	0	2	0	1011	SHELTER#
76	1200	1200	50	140	0	2	0	1012	SHELTER#
88	6450	1900	50	100	0	2	0	1017	SHELTER#
90	6700	1950	100	50	0	2	0	1018	SHELTER#
			** TARGET TYPE # 3 **						
105	1000	0	150	1000	0	3	0	2001	TXWY# 1
106	2000	0	150	1000	0	3	0	2002	TXWY# 2
107	3000	0	150	1000	0	3	0	2003	TXWY# 3
145	6950	1350	400	50	0	3	0	2041	TXWY#41
146	7000	1350	50	200	0	3	0	2042	TXWY#42
147	6950	1050	300	50	0	3	0	2043	TXWY#43
148	6600	1050	200	50	0	3	0	2044	TXWY#44
149	6100	1050	200	50	0	3	0	2045	TXWY#45
			** TARGET TYPE # 4 **						
3	3000	1050	250	1250	0	4	0	3001	RAMP A
4	4350	800	200	900	0	4	0	3002	RAMP B
			** TARGET TYPE # 5 **						
5	3650	1300	250	75	0	5	0	1	SHOP #1
6	3000	1300	200	75	0	5	0	2	SHOP #2
7	3075	1400	100	175	0	5	0	3	SHOP #3
8	3725	1450	100	125	0	5	0	5	SHOP #5
9	3850	1300	250	100	0	5	0	7	SHOP #7
10	4750	1250	100	200	0	5	0	9	SHOP #9
			** TARGET TYPE # 17 **						
79	5550	1200	100	50	0	17	0	1013	SHELTER#
81	5450	1450	50	100	0	17	0	1014	SHELTER#
83	5950	1900	50	140	0	17	0	1015	SHELTER#
86	6200	1950	100	50	0	17	0	1016	SHELTER#
			** TARGET TYPE # 18 **						
80	5550	1300	100	50	0	18	0	4013	SHELTER#
82	5550	1450	50	100	0	18	0	4014	SHELTER#
84	6090	1900	50	100	0	18	0	4015	SHELTER#
87	6200	1850	100	50	0	18	0	4016	SHELTER#

Fig. 19—TSARINA record of target-related input data

** MONITORING POINTS **

NO.	X	Y	NO.	X	Y	NO.	X	Y	NO.	X	Y	NO.	X	Y	NO.	X	Y
1	1500	75	2	2500	75	3	3500	75	4	4500	75	5	5500	75	6	6500	75
7	1025	650	8	4025	650	9	6975	650	10	2600	1025	11	3600	1025	12	4850	1025
13	900	1375	14	1375	1850	15	1875	1850	16	2350	1375	17	1875	1150	18	1375	1150
19	1650	1450	20	3450	1550	21	4400	1550	22	5650	1375	23	6125	1850	24	6625	1850
25	7100	1375	26	6625	1150	27	6125	1150	28	6400	1450	29	4700	2400	30	3150	2400

ATTACK DATA

NUMBER	HDG	UNC	X-DMPI	Y-DMPI	REP	DEP	R-DISP	D-DISP	ANGLE	NO WPNS	LENGTH	HTH	TYPE	ARRIVAL
1	75	5	3000	75	150	45	60	53	0	10	800	0	1	95
2	75	5	3000	75	150	45	60	53	0	10	800	0	1	95
3	75	5	3000	75	150	45	60	53	0	10	800	0	1	95
4	75	5	3000	75	150	45	60	53	0	10	800	0	1	95
5	75	5	5000	75	150	45	60	53	0	10	800	0	1	95
6	75	5	5000	75	150	45	60	53	0	10	800	0	1	95
7	75	5	5000	75	150	45	60	53	0	10	800	0	1	95
8	75	5	5000	75	150	45	60	53	0	10	800	0	1	95
9	75	5	3000	1025	150	45	60	53	0	10	800	0	1	95
10	75	5	3000	1025	150	45	60	53	0	10	800	0	1	95
11	75	5	5000	1025	150	45	60	53	0	10	800	0	1	95
12	75	5	5000	1025	150	45	60	53	0	10	800	0	1	95
13	90	2	4000	75	150	75	100	65	0	5	5000	0	3	90
14	90	2	10000	1025	150	75	100	65	0	5	5000	0	3	90
15	90	10	1800	1200	150	45	60	53	0	10	800	0	1	95
16	90	10	6500	1200	150	45	60	53	0	10	800	0	1	95
17	90	10	1800	1800	150	45	60	53	0	10	800	0	1	95
18	90	10	6400	1800	150	45	60	53	0	10	800	0	1	95
19	20	5	1700	1600	150	75	75	35	0	6	2000	980	5	90
20	20	5	3800	1600	150	75	75	35	0	6	2000	980	5	90
21	20	5	5900	1600	150	75	75	35	0	6	2000	980	5	90

METEOROLOGICAL DATA

STABILITY CATEGORY 2 TEMPERATURE 60.0 F ATMOS. PRESSURE 760.0 TORRS

MEAN WIND DIRECTION 156. DEGREES DIRECTION UNC. 10.DEG MEAN WIND VELOCITY 6.7 MPH VELOCITY UNC. 20.MPH*10

Fig. 20—TSARINA listing of the monitoring points, attack data, and meteorological data

```
                                                    U - X - O   DATA
             WPN  PERCENT   RADIUS OF     DELAY                        EXPLOSION DAMAGE DATA
             TYPE   UXO     INFLUENCE   MIN   MAX           AT EXPLOSION              SAME TAXIWAY     ADJACENT
                                                      CASUALTIES  DEAD   EQUIP   CASUALTIES   EQUIP   CASUALTIES

              1      20        250       20    80        50        50     75         25         10        10          0
              2      15        100       40   100        25        20     50         15         10        10          0

                                             MISS DISTANCE AND KILL PROBABILITY DATA

                                                          TARGET TYPES
                          1        2        3        4        5        6        7        8        9       10

TARGET HEIGHT             0        0        0        0        0        0        0        0        0        0

WPN TYPE   WPN REL
   1        0.950        20        2       20       20      100        2       20      120        4        5      150      16
                          0      150       40       40      140      150       40       35      100       40
                          0       75   120080   120080       75       75       75    80080        0    90095
                          0       55    90075    90075       15       55       15        0        0        0
                          0       35   120100   120100       24       35       26        0        0        0
                          0       40    80080    80080       17       40        0        0       80        0
                          0       45        0        0       29       45        0        0        0        0
                          0        0        0        0        0        0        0        0        0        0
                          0   333330   777600   777600   123120   333330   222000   700000      300   800000
                         -1      100       -1       -1       -1       -1       -1       -1       -1       -1
                          0        0        0        0        0        0        0        0        0        0
                          0       55        0        0        0        0        0        0        0        0
                          0       68        0        0        0        0        0        0        0        0
                          0       33        0        0        0        0        0        0        0        0
                          0       40        0        0        0        0        0        0        0        0
                          0       12        0        0        0        0        0        0        0        0

                                                          TARGET TYPES
                         11       12       13       14       15       16       17       18       19       20

TARGET HEIGHT             0        0        0        0        0        0        0        0        0        0

                         60       20       20       30      120       10       30       75      100       50
                          0       40       40       40       35      150      150       70       90       80
                         65   120080   120080   120080    80090       90       50       70       90       80
                          0    90075    80100    70090        0       75       35       70       90       80
                          0        0        0        0        0       50       25       90       95       50
                          0        0        0       50        0       50       25       80       70       90
                          0        0        0        0        0       50       25       20       50       45
                          0        0    60100        0        0        0        0       40       25       30
                     100000   770000   760006   760600   700000   333330   333330   121212   121212   121212
                         80       -1       -1       -1        0       75       50       -1       -1       -1
                          0        0        0        0       50        0        0        0        0        0
                         80        0        0        0   100100       60       40        0        0        0
                          0        0        0        0        0       50       35        0        0        0
                          0        0        0        0        0       40       30        0        0        0
                          0        0        0        0        0       30       25        0        0        0
                          0        0        0        0        0       20       20        0        0        0

                                                          TARGET TYPES
                          1        2        3        4        5        6        7        8        9       10

WPN TYPE   WPN REL
   2        0.950         5        0        5        5       15        0       10       10        0       10        9       9
                          0        0       10       10       30       -1       15       20       -1       20
                          0        0    40050    40080       50        0       40       60        0       40
                          0        0    20050    25080       30        0       25        0        0        0
                          0        0    30100    30100       25        0       20        0        0        0
                          0        0    20100    20100       30        0        0        0        0        0
                          0        0        0        0       30        0        0        0        0        0
                          0        0        0        0        0        0        0        0        0        0
                          0        0   767600   777600   333110        0   333000   300000        0   300000

                                                          TARGET TYPES
                         11       12       13       14       15       16       17       18       19       20

                         15        5        5        5       15        0        0        0        0        0
                          0       10       10       10        0        0        0       -1       -1       -1
                      30050    40080    40080    40030    30080        0        0        0        0        0
                          0    25080    20050    20050        0        0        0        0        0        0
                          0        0        0        0        0        0        0        0        0        0
                          0        0        0    20090        0        0        0        0        0        0
                          0        0        0        0        0        0        0        0        0        0
                          0        0       80        0        0        0        0        0        0        0
                     600000   770000   760003   760600   600000        0        0        0        0        0

                                                          TARGET TYPES
                          1        2        3        4        5        6        7        8        9       10

WPN TYPE   WPN REL
   4        1.000        -1     6977     2906     2319        0       67       53     2500     1000        1        0       3
                          0     3779     1889     2473        0       67      350     3300     1400        1
                          0     1775      872     2932        0       67     1287     3600     2200        1

                                                          TARGET TYPES
                          1        2        3        4        5        6        7        8        9       10

WPN TYPE   WPN REL
   5        1.000        -1     1840      490      360        0       67       24     3700      800        1        0       3
                          0     1020      380      395        0       67      287     4000     1500        1
                          0      525      230      440        0       67     2582     5000     3000        1
```

Fig. 21—Weapon effectiveness input data for TSARINA

***** TARGET HIT SUMMARY TRIAL 2 *****

TGT NO.	NUMBER HITS TOT	OUT		CBU COVERAGE	BOMB COVERAGE R1	R2	********** KILL PROBABILITIES ********** PEOPLE	AGE	PARTS	AMMO	TRAP	MATRL	SURFACE DEPOSITION DOSE1	DOSE2	DOSE3	****** FACILITY **** NO.	NAME
							** TARGET TYPE # 1 **										
1	50	10		0.000	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2196	0	0	0	RUNWAY
2	13	7		0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2341	0	0	0	MAIN TAX
							** TARGET TYPE # 2 **										
66	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	85	0	0	1007	SHELTER
74	0	0		0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1011	SHELTER#
76	0	0		0.000	0.000	0.707	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1012	SHELTER#
88	2	0		0.000	0.005	1.000	0.938	0.798	0.577	0.640	0.697	0.000	1919	0	0	1017	SHELTER#
90	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	434	0	0	1018	SHELTER#
94	0	0		0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1020	SHELTER#
96	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2197	0	0	1021	SHELTER#
99	0	0		0.000	0.000	0.894	0.000	0.000	0.000	0.000	0.000	0.000	438	0	0	1022	SHELTER#
101	0	0		0.000	0.000	0.174	0.000	0.000	0.000	0.000	0.000	0.000	2652	0	0	1023	SHELTER#
103	0	0		0.000	0.000	0.854	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1024	SHELTER#
							** TARGET TYPE # 3 **										
			MINES														
105	0	0	24	0.156	0.000	0.000	0.070	0.039	0.055	0.031	0.000	0.000	2667	0	0	2001	TXWY# 1
106	7	0	72	0.469	0.000	0.183	0.493	0.339	0.521	0.219	0.000	0.000	209	0	0	2002	TXWY# 2
107	15	0	106	0.688	0.000	0.416	0.782	0.617	0.822	0.420	0.000	0.000	2176	0	0	2003	TXWY# 3
108	7	0	72	0.469	0.000	0.216	0.544	0.380	0.580	0.246	0.000	0.000	165	0	0	2004	TXWY# 4
109	11	0	96	0.625	0.000	0.284	0.657	0.481	0.692	0.320	0.000	0.000	684	0	0	2005	TXWY# 5
110	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1374	0	0	2006	TXWY# 6
111	0	0	0	0.000	0.000	0.000	0.005	0.000	0.006	0.000	0.000	0.000	0	0	0	2007	TXWY# 7
112	0	0	0	0.000	0.000	0.000	0.016	0.000	0.020	0.000	0.000	0.000	834	0	0	2008	TXWY# 8
113	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5656	0	0	2009	TXWY# 9
114	2	0	0	0.000	0.030	0.266	0.462	0.346	0.543	0.213	0.000	0.000	367	0	0	2010	TXWY#10
115	1	0	0	0.000	0.019	0.092	0.175	0.123	0.215	0.075	0.000	0.000	1338	0	0	2011	TXWY#11
138	0	0	0	0.000	0.000	0.000	0.065	0.007	0.081	0.000	0.000	0.000	0	0	0	2034	TXWY#34
141	0	0	0	0.000	0.000	0.000	0.207	0.077	0.254	0.049	0.000	0.000	0	0	0	2037	TXWY#37
142	0	0	0	0.000	0.000	0.000	0.010	0.000	0.013	0.000	0.000	0.000	2805	0	0	2038	TXWY#38
143	0	0	0	0.000	0.000	0.000	0.119	0.012	0.148	0.001	0.000	0.000	3610	0	0	2039	TXWY#39
144	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3615	0	0	2040	TXWY#40
145	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	35	0	0	2041	TXWY#41
147	0	0	16	0.750	0.000	0.000	0.337	0.188	0.262	0.150	0.000	0.000	279	0	0	2043	TXWY#43
148	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	409	0	0	2044	TXWY#44
149	0	0	0	0.000	0.000	0.057	0.316	0.178	0.384	0.120	0.000	0.000	35	0	0	2045	TXWY#45
							** TARGET TYPE # 4 **										
3	3	1		0.000	0.008	0.033	0.071	0.046	0.088	0.029	0.000	0.000	2397	0	0	3001	RAMP A
4	4	0		0.000	0.028	0.099	0.220	0.146	0.269	0.095	0.000	0.000	79	0	0	3002	RAMP B
							** TARGET TYPE # 5 **										
5	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	76	0	0	1	SHOP #1
9	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	787	0	0	7	SHOP #7
10	0	0		0.000	0.000	0.132	0.000	0.020	0.000	0.000	0.038	0.000	0	0	0	9	SHOP #9
15	0	0		0.000	0.000	0.186	0.000	0.028	0.000	0.000	0.054	0.000	169	0	0	28	AMMO SHO
17	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	548	0	0	27	RCFG #1
21	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	438	0	0	46	TOWER
22	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	44	0	0	48	APPROACH
35	0	0		1.000	0.000	0.000	0.050	0.000	0.000	0.000	0.000	0.000	0	0	0	0	CE WAIT2
							** TARGET TYPE # 18 **										
82	1	0		0.000	0.370	0.322	0.259	0.225	0.333	0.258	0.074	0.129	0	0	0	4014	SHELTER#
							** TARGET TYPE # 19 **										
69	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2504	0	0	4008	SHELTER
71	1	0		0.000	0.678	0.578	0.610	0.520	0.644	0.405	0.339	0.145	2652	0	0	4009	SHELTER
73	0	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	22	0	0	4010	SHELTER#

PERCENT EXPOSED AIRCRAFT DAMAGED/DESTROYED ON PARKING RAMPS: 15/ 5 AND ON TAXIWAYS: 31/ 13

PERCENT SHELTERED AIRCRAFT DAMAGED/DESTROYED WHEN DOORS OPEN: 13/ 46 WHEN DOORS CLOSED: 0/ 13

** MONITORING POINTS **

NO.	DOSE1	VAPR1	DOSE2	VAPR2	DOSE3	VAPR3	NO.	DOSE1	VAPR1	DOSE2	VAPR2	DOSE3	VAPR3	NO.	DOSE1	VAPR1	DOSE2	VAPR2	DOSE3	VAPR3
1	285	205	0	0	0	0	2	44	2325	0	0	0	0	3	2652	675	0	0	0	0
4	22	1780	0	0	0	0	5	0	0	0	0	0	0	6	592	4449	0	0	0	0
7	0	0	0	0	0	0	8	570	4432	0	0	0	0	9	44	3215	0	0	0	0
10	285	902	0	0	0	0	11	0	0	0	0	0	0	12	0	8	0	0	0	0
13	0	0	0	0	0	0	14	0	0	0	0	0	0	15	0	0	0	0	0	0
16	2652	3273	0	0	0	0	17	22	83	0	0	0	0	18	0	0	0	0	0	0
19	0	0	0	0	0	0	20	0	0	0	0	0	0	21	285	3333	0	0	0	0
22	0	0	0	0	0	0	23	0	0	0	0	0	0	24	2937	2023	0	0	0	0
25	0	14	0	0	0	0	26	307	4674	0	0	0	0	27	22	37	0	0	0	0
28	307	143	0	0	0	0	29	0	0	0	0	0	0	30	0	0	0	0	0	0

Fig. 22—TSARINA hit summary, aircraft damage summary, and deposition at the monitoring points for Trial #2

Six of the taxiways that are shown were hit by bombs, and mines fell on 6; 17 sustained chemical deposition. Both ramps sustained hits; the fractional losses to personnel, equipment, or aircraft on these ramps at the time of the attack are also noted. On ramp B, for example, 22.0 percent of the personnel, 14.6 percent of the equipment, and 26.9 percent of the aircraft would be lost or damaged; 9.5 percent of the aircraft would be damaged beyond repair.

A summary of the expected loss rates for aircraft in different locations is given next, followed—for CW attacks—by a record of the initial intensity of the liquid contamination on the surface and the initial vapor concentration at each of the monitoring points for each of the agents that was employed.

The optional pictorial representation of the bomb craters and the centroids of the mine dispensers is shown in Fig. 23. Only the center of each crater is depicted using an asterisk; the dimensions of the craters are not represented. The "+" signs denote the centroid of dispensers that affect the runway. The locations selected that required the least numbers of crater repairs for an MOS are shown with the dotted lines; six crater repairs would be required on the runway and five on the main taxiway. Note that the location for the fewest repairs on the runway is skewed 2.25 degrees from the runway edge, with the suggested MOS running from one side of the surface to almost the other side.

The fractional losses for all of the resource types present on the base—modified as required by the EQUI cards—are shown in Fig. 24 as they would be formatted for transfer to TSAR. These TSAR #40 Card data begin with a card image that identifies the time and place of the attack and several characteristics of attack. The next several cards (5 in this example) transfer the data that define the percentages of the different personnel types associated with each target type and each monitoring point. The loss rate data for the personnel, equipment, spares, ammo, and building materials that were specified in the TSARINA resource data are listed next. These data also include summaries of the damage sustained by the taxiways, aircraft shelters, and other facilities. The last data (with the '10' in columns 24/25) identify the closest monitoring point for each facility, each taxiway, each shelter, and each ramp. These latter data are only transferred for the first of a sequence of attacks on an airbase.

The statistical results for the five trials are presented in Figs. 25, 26, and 27. The first figure indicates the fraction of trials in which at least one hit was sustained, as well

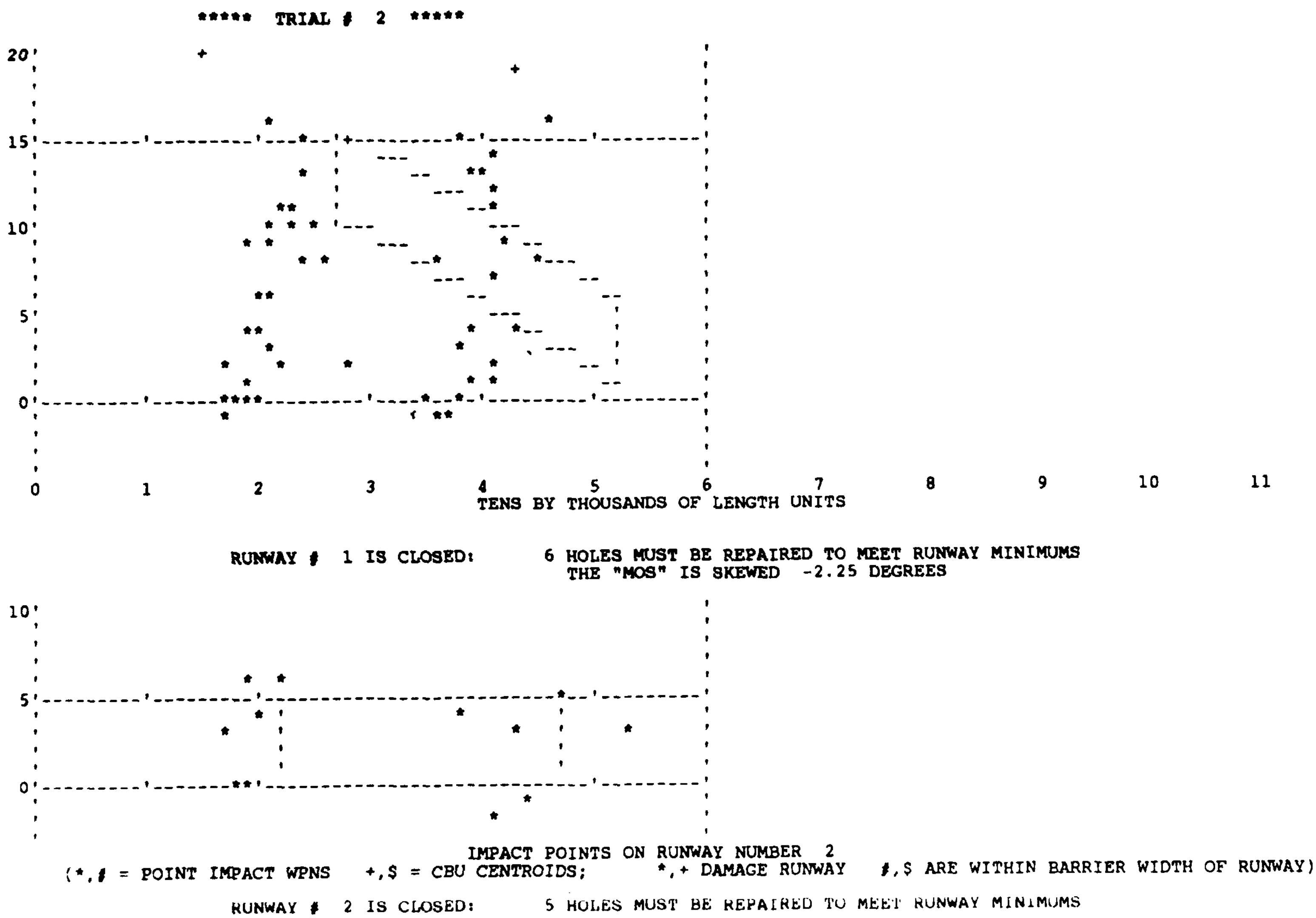

Fig. 23—Optional TSARINA output illustrating runway craters and preferred MOS location

```
40  1    1    7   18    1      3     -1     2     0     0    33  164    60    3010200 3056
40  0    0    0    0   10      630191     705   500  2505   50030192   705   500 2505   500
40  0    0    0    0   10      630194     705   500  2505   50030101  1207 [illegible] 1907   200
40  0    0    0    0   10      6 1908     100  2005   100  2008   100  2108   100 2707   200
40  0    0    0    0   10      6 2808     10031003  2915   340  3015   66031003 2915   600
40  0    0    0    0   10      6 3015     400     0     0     0     0     0     0    0     0
40  0    0    0    0    1   191      3     1   192     3     1   194     3     1  101     2
40  0    0    0    0    1  1003      0     0     0     0     0     0     0     0    0     0
40  0    0    0    0    1  1000      0     0     0     0     0     0     0     0    0     0
40  0    0    0    0    2     2      9     2     3     9     2    96     0     2   97     0
40  0    0    0    0    2    99      0     2    16     3     2    17     3     2   18     3
40  0    0    0    0    2    21      0     2    23     0     0     0     0     0    0     0
40  0    0    0    0    3     3      2     310002     1     3    12     2     310003     2
40  0    0    0    0    3     0      0     0     0     0     0     0     0     0    0     0
40  0    0    0    0    4     1      9     4     2     9     4     3     9     4    4     9
40  0    0    0    0    4     5      9     4    11     0     4    12     2     4   41     0
40  0    0    0    0    4    42      0     4    43     0     4   202     0     4  203     0
40  0    0    0    0    4   204      0     4   205     0     0     0     0     0    0     0
40  0    0    0    0    4     0      0     0     0     0     0     0     0     0    0     0
40  0    0    0    0    5     1      3     5     2     3     5     3     3     5    4     3
40  0    0    0    0    5     5      3     0     0     0     0     0     0     0    0     0
40  0    0    0    0    9     1      0     0     0     0    76     0     0
40  0    0    0    0    9     7      0     0     0     0   787     0     0
40  0    0    0    0    9     9      0     0     2     0     0     0     0
40  0    0    0    0    9    10      4    12     2     4     0     0     0
40  0    0    0    0    9    27      0     0     0     0   548     0     0
40  0    0    0    0    9    28      0     0     3     0   169     0     0
40  0    0    0    0    9    32      0     0     0     0  2197     0     0
40  0    0    0    0    9    40      0     0     0     0   219     0     0
40  0    0    0    0    9    46      0     0     0     0   438     0     0
40  0    0    0    0    9    48      0     0     0     0    44     0     0
40  0    0    0    0    9    52      0    75    55    35     0     0     0
40  0    0    0    0    9   102      0     0     0     0    16     0     0
40  0    0    0    0    9   123      0     0     0     0   286     0     0
40  0    0    0    0    9   124      0     0     0     0   979     0     0
40  0    0    0    0    9    38     25  3981     0     1     0     0     0
40  0    0  100 1536    0   900   2667     0     0   200  4610     0  6306   209    0     0
40  0    0  300 6786    010046   2176     0     0   400  4614     0  6950   165    0     0
40  0    0  500 6145    0  8496    684     0     0   600     0     0     0  1374    0     0
40  0    0  700    2    0     0      0     0     0   800     0     0   256   834    0     0
40  0    0  900    1    0     0   5656     0     0  1004     2     0  5923   367    0     0
40  0    0 1103    1    0  2188   1338     0     0  1203     3     0  1801   37[illegible]    0     0
40  0    0 1304    0    0  4378      0     0     0  1400     1     0  3083     0    0     0
40  0    0 1504    0    0  3473   26[illegible]     0     0  1600   832     0  3600   515    0     0
40  0    0 1700  896    0  1414      0     0     0  1800   448     0   771  2302    0     0
40  0    0 1900    0    0     0     98     0     0  2000     1     0   640     0    0     0
40  0    0 2408    0    0  4635      0     0     0  2604     0     0  6694     0    0     0
40  0    0 3400    2    0   897      0     0     0  4300  1024     0  4371   279    0     0
40  0    0 4400    1    0     0    409     0     0     0     0     0     0     0    0     0
40  0    0    0    0    9    39      2     0     0     0     0     0     0     0    0     0
40  0    0    0    0    1   901   1155  2397     0     0     2  2831  3466    79
40  0    0    0    0    8    24     20     1  2000     0     0     0     0     0    0     0
40  0    0    0    0  302     0      0     0     0     0   902     0     0     0    0     0
40  0    0    0    0 1242     15010803     0     0     0  1501     0   900     0    0     0
40  0    0    0    0 1862     18011704     0     0     0  2100     0     0    85    0     0
40  0    0    0    0 2400     0      0  1024     0     0  2742   45011716  2652    0     0
40  0    0    0    0 3002     0      0     0     0     0  3342   15010803     0    0     0
40  0    0    0    0 3602     0      0     0     0     0  42091125910992     0    0     0
40  0    0    0    0 450811169   8286     0     0     0  4809176812941     0    0     0
40  0    0    0    0 51002141018434  19[illegible]     0     0  5400     0     0   434    0     0
40  0    0    0    0 6300     0      0  2197     0     0  6601     0     0   438    0     0
40  0    0    0    0 6900     0      0  2652     0     0  7201     0     0     0    0     0
40  0    0    0    0   10     1      1    20     2    20     3    20     5    20    7    20
40  0    0    0    0   10     1      9    12    10    12    27    15    28    15   30    30
40  0    0    0    0   10     1     31    18    32    26    40    15    41    23   44    14
40  0    0    0    0   10     1     46    21    48     6    51    15    52    23   62    14
40  0    0    0    0   10     1     71    22   101    19   102    27   111    23  112    23
40  0    0    0    0   10     1    121    19   122    20   123    21   124    28  125    14
40  0    0    0    0   10     1    126    30     0     0     0     0     0     0    0     0
40  0    0    0    0   10     2      1     2     3     4     5     6    18    17   17    10
40  0    0    0    0   10     2     11    12    22    27    26    26     7     8    9    13
40  0    0    0    0   10     2     13    13    14    14    14    15    15    16   16    16
40  0    0    0    0   10     2     17    18    22    22    22    23    23    23   24    24
40  0    0    0    0   10     2     25    25    25    26    27     0     0     0    0     0
40  0    0    0    0   10     3    131   131   141   141   151   151   161   162  172   172
40  0    0    0    0   10     3    181   181   223   223   233   233   241   241  251   251
40  0    0    0    0   10     3    261   261   271   271     0     0     0     0    0     0
40  0    0    0    0   10     4     11    12     0     0     0     0     0     0    0     0
40  0    0    0    0   10     5   1006    51     0  1012    31     0  1015    52    0  102[illegible]
40  0    0    0    0   10     5     32     0     0     0     0     0     0     0    0     0
40  0    0    0    0   10     7      1    20    80    50    50    75    25    10   10     0
40  0    0    0    0   10     7      2    40   100    25    20    50    15    10   10     0
40  0    0    0    0   11     0      0     0     0     0     0     0     0     0    0     0
```

Fig. 24—TSARINA formatted Type #40 Cards for entry into TSAR

as the expected number, and standard deviation, of hits fo- each target. Comparable results are provided for dispenser weapons, as can be noted for several taxiways. The results labeled "Bomb Coverage" are the expected fractions of the facility floor-space affected by the two coverage radii, R1 and R2. The average losses sustained at each target by the six classes of resources are listed just right of center on Fig. 25. The arithmetic average of the initial surface deposition of chemical agents for the five trials are listed next, followed by the target descriptors. A summary of the runway closures and the required runway repairs is noted at the bottom of this figure.

Figure 26 presents an example of additional runway damage data that the user may request. These data provide the cumulative distribution of crater repairs required to clear an MOS on each runway and on the base as a whole. In this illustration, repairs were required on the main runway (Target #1) in all but 1 of 25 trials; 1 repair was required on 3 trials, 4 for 3 trials, etc.; in the worst case, 8 craters required repair for an MOS on 1 trial. The parallel taxiway (Target #2) was closed for all trials, but required 3 or fewer repairs in 80 percent of the trials; 6 repairs were required in the worst case. When both surfaces are considered, an MOS could be opened with 2 repairs in 64 percent of the trials; and 5 repairs was the worst case.

Finally, Fig. 27 presents the average losses sustained by each type of resource for the 5 trials, along with the standard deviation of those losses. When TSARINA is used as a general-purpose damage assessment model, these statistical results are one of the primary output; they are not transferred to TSAR, however, since TSAR only uses the trial-by-trial results. Figure 27 also presents the average percentages of aircraft that would be damaged and destroyed on ramps and on taxiways, and the percentages of aircraft that would be damaged and destroyed in shelters, both with and without the shelter doors open.

***** TARGET DAMAGE STATISTICS FOR 5 TRIALS *****

TGT NO.	%TRIALS HIT	AVE. HITS	HIT S.DEV	CBU COVER.	CBU S.DEV	BOMB COVERAGE R1	BOMB COVERAGE R2	KILL PROBABILITIES PEOPLE	AGE	PARTS	AMMO	TRAP	MATRL	SURFACE DEPOSITION DOSE1	DOSE2	DOSE3	FACILITY NO	FACILITY NAME
*** TARGET TYPE # 1 ***																		
1	100.0	34.20	9.31	0.00	0.00	0.039	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2015	0	0		RUNWAY
2	100.0	10.20	5.02	0.00	0.00	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1559	0	0		MAIN TAX
*** TARGET TYPE # 2 ***																		
53	0.0	0.00	0.00	0.00	0.00	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1001	SHELTER
57	0.0	0.00	0.00	0.00	0.00	0.000	0.194	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1003	SHELTER
59	0.0	0.00	0.00	0.00	0.00	0.000	0.403	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1004	SHELTER
61	0.0	0.00	0.00	0.00	0.00	0.000	0.494	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1005	SHELTER
63	0.0	0.00	0.00	0.00	0.00	0.000	0.939	0.000	0.000	0.000	0.000	0.000	0.000	24	0	0	1006	SHELTER
90	0.0	0.00	0.00	0.00	0.00	0.000	0.068	0.000	0.000	0.000	0.000	0.000	0.000	87	0	0	1018	SHELTER#
92	0.0	0.00	0.00	0.00	0.00	0.000	0.054	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1019	SHELTER#
94	20.0	0.20	0.45	0.30	0.45	0.001	0.354	0.150	0.110	0.070	0.080	0.090	0.000	0	0	0	1020	SHELTER#
96	0.0	0.00	0.00	0.00	0.00	0.000	0.380	0.000	0.000	0.000	0.000	0.000	0.000	507	0	0	1021	SHELTER#
99	0.0	0.00	0.00	0.00	0.00	0.000	0.908	0.000	0.000	0.000	0.000	0.000	0.000	772	0	0	1022	SHELTER#
101	20.0	0.20	0.45	0.00	0.00	0.001	0.424	0.150	0.110	0.070	0.080	0.090	0.000	1591	0	0	1023	SHELTER#
103	20.0	0.20	0.45	0.00	0.00	0.001	0.491	0.150	0.110	0.070	0.080	0.090	0.000	935	0	0	1024	SHELTER#
*** TARGET TYPE # 3 ***																		
105	0.0	0.00	0.00	0.53	0.32	0.000	0.000	0.239	0.133	0.186	0.106	0.000	0.000	1908	0	0	2001	TXWY# 1
106	100.0	5.80	1.30	0.32	0.36	0.000	0.176	0.457	0.312	0.498	0.197	0.000	0.000	245	0	0	2002	TXWY# 2
107	100.0	11.80	2.39	0.41	0.34	0.000	0.318	0.630	0.476	0.684	0.305	0.000	0.000	1201	0	0	2003	TXWY# 3
108	100.0	5.40	3.05	0.31	0.22	0.000	0.159	0.413	0.282	0.447	0.178	0.000	0.000	179	0	0	2004	TXWY# 4
109	100.0	6.40	2.79	0.21	0.26	0.000	0.175	0.419	0.285	0.471	0.175	0.000	0.000	1173	0	0	2005	TXWY# 5
110	0.0	0.00	0.00	0.30	0.28	0.000	0.000	0.135	0.075	0.105	0.060	0.000	0.000	520	0	0	2006	TXWY# 6
111	0.0	0.00	0.00	0.00	0.00	0.000	0.024	0.037	0.029	0.046	0.015	0.000	0.000	0	0	0	2007	TXWY# 7
112	20.0	0.20	0.45	0.00	0.00	0.008	0.036	0.125	0.077	0.151	0.052	0.000	0.000	299	0	0	2008	TXWY# 8
113	20.0	0.20	0.45	0.00	0.00	0.011	0.040	0.115	0.069	0.143	0.044	0.000	0.000	3804	0	0	2009	TXWY# 9
144	20.0	0.40	0.89	0.00	0.00	0.020	0.084	0.142	0.102	0.172	0.061	0.000	0.000	1023	0	0	2040	TXWY#40
145	0.0	0.00	0.00	0.00	0.00	0.000	0.002	0.021	0.010	0.027	0.007	0.000	0.000	8	0	0	2041	TXWY#41
146	0.0	0.00	0.00	0.00	0.00	0.000	0.019	0.056	0.035	0.069	0.020	0.000	0.000	0	0	0	2042	TXWY#42
147	60.0	0.60	0.55	0.35	0.49	0.041	0.135	0.358	0.239	0.377	0.166	0.000	0.000	126	0	0	2043	TXWY#43
148	40.0	0.40	0.55	0.00	0.00	0.047	0.179	0.287	0.211	0.352	0.129	0.000	0.000	437	0	0	2044	TXWY#44
149	0.0	0.00	0.00	0.00	0.00	0.000	0.011	0.091	0.038	0.111	0.024	0.000	0.000	1492	0	0	2045	TXWY#45
*** TARGET TYPE # 4 ***																		
3	100.0	4.60	1.82	0.00	0.00	0.017	0.066	0.139	0.094	0.171	0.060	0.000	0.000	1830	0	0	3001	RAMP A
4	100.0	7.00	4.24	0.00	0.00	0.042	0.157	0.315	0.221	0.374	0.147	0.000	0.000	241	0	0	3002	RAMP B
*** TARGET TYPE # 5 ***																		
5	0.0	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15	0	0	1	SHOP #1
6	20.0	0.20	0.45	0.00	0.00	0.010	0.049	0.007	0.007	0.012	0.002	0.014	0.000	5	0	0	2	SHOP #2
9	0.0	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	198	0	0	7	SHOP #7
10	0.0	0.00	0.00	0.00	0.00	0.000	0.026	0.000	0.004	0.000	0.000	0.008	0.000	92	0	0	9	SHOP #9
14	0.0	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1128	0	0		WAREHAUS
15	60.0	1.00	1.00	0.00	0.00	0.421	0.615	0.326	0.123	0.182	0.079	0.227	0.000	1110	0	0	28	AMMO SHO
17	40.0	0.40	0.55	0.00	0.00	0.346	0.445	0.259	0.067	0.096	0.059	0.129	0.000	1628	0	0	27	RCPG #1
21	0.0	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1329	0	0	46	TOWER
*** TARGET TYPE # 6 ***																		
65	0.0	0.00	0.00	0.00	0.00	0.000	0.939	0.000	0.000	0.000	0.000	0.000	0.000	24	0	0	51	SQD #1 A
78	0.0	0.00	0.00	0.00	0.00	0.000	0.360	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	31	SQD #1
85	20.0	0.20	0.45	0.00	0.00	0.000	0.352	0.150	0.110	0.070	0.080	0.090	0.000	4	0	0	52	SQD #2 A
98	0.0	0.00	0.00	0.00	0.00	0.000	0.380	0.000	0.000	0.000	0.000	0.000	0.000	507	0	0	32	SQD #2
*** TARGET TYPE # 17 ***																		
79	0.0	0.00	0.00	0.00	0.00	0.000	0.437	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	1013	SHELTER#
81	100.0	1.60	0.55	0.00	0.00	0.099	1.000	0.650	0.486	0.362	0.362	0.362	0.000	0	0	0	1014	SHELTER#
83	20.0	0.20	0.45	0.00	0.00	0.071	0.352	0.100	0.070	0.050	0.050	0.050	0.000	4	0	0	1015	SHELTER#
86	20.0	0.40	0.89	0.00	0.00	0.095	0.219	0.150	0.115	0.087	0.087	0.087	0.000	1219	0	0	1016	SHELTER#
*** TARGET TYPE # 18 ***																		
82	100.0	1.00	0.00	0.00	0.00	0.370	0.322	0.259	0.225	0.333	0.258	0.074	0.129	0	0	0	4014	SHELTER#
84	0.0	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	243	0	0	4015	SHELTER#
87	0.0	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1197	0	0	4016	SHELTER#

ALL RUNWAYS WERE CLOSED 100.0% OF THE TIME; AT LEAST ONE SURFACE WAS OPEN AFTER 0.0% OF THE ATTACKS

WHEN ALL RUNWAYS WERE CLOSED, 2.80(2.05) HOLES REQUIRED REPAIR, ON THE AVERAGE, TO PROVIDE A MINIMUM RUNWAY

Fig. 25—TSARINA multiple trial hit statistics

ALL RUNWAYS WERE CLOSED 96.0% OF THE TIME; AT LEAST ONE SURFACE WAS OPEN AFTER 4.0% OF THE ATTACKS

WHEN ALL RUNWAYS WERE CLOSED, 2.33(1.24) HOLES REQUIRED REPAIR, ON THE AVERAGE, TO PROVIDE A MINIMUM RUNWAY

CUMULATIVE DISTRIBUTION OF REQUIRED CRATER REPAIRS [0, 1 (1) 50 REPAIRS]

TARGET # 1

NO REPAIRS 0.040

0.160	0.320	0.520	0.600	0.880	0.960	0.960	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

TARGET # 2

NO REPAIRS 0.000

0.240	0.560	0.800	0.880	0.960	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

OVERALL DISTRIBUTION FOR REPAIRS

NO REPAIRS 0.040

0.320	0.640	0.840	0.920	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Fig. 26—Illustrative TSARINA runway crater repair output

RESOURCE CLASS	TYPE	AVERAGE LOSSES PERCENT	STD DEV LOSSES PERCENT	AVERAGE DOSE1 (MG/M2)	AVERAGE DOSE2 (MG/M2)	AVERAGE DOSE3 (MG/M2)
PEOPLE	1	1.200	1.308	0	0	0
	101	0.800	0.814	431	0	0
	1000	0.000	0.000	343	0	0
	1003	0.000	0.000	194	0	0
AGE	2	3.700	3.221			
	3	3.140	3.289			
	4	2.540	2.597			
	16	1.740	1.563			
PARTS	ALL	0.000	0.000			
PARTS	3	0.740	0.684			
	8	0.560	0.588			
	12	1.180	1.103			
	112	0.880	0.832			
AMMO	ALL	0.000	0.000			
AMMO	2	5.740	5.287			
	3	5.740	5.287			
	12	0.680	0.787			
TRAP	2	4.460	2.192			
	3	2.880	3.040			
	4	0.880	2.023			

EXPECTED AIRCRAFT DAMAGE IN QRA SHELTERS: 0.0 (0.0) PERCENT
EXPECTED DAMAGE TO QRA SHELTERS: 0.0 (0.0) PERCENT

EXPECTED PERCENT OF AIRCRAFT DAMAGED/DESTROYED ON PARKING RAMPS: 24/ 9 AND ON TAXIWAYS: 29/ 12

PERCENT OF SHELTERED AIRCRAFT DAMAGED/DESTROYED WITH OPEN DOORS: 13/ 19 WITH CLOSED DOORS: 1/ 6

TOTAL EXECUTION TIME 13.307 SEC

Fig. 27—TSARINA multiple trial resource loss statistics

Appendix A

DETAILED DESCRIPTION OF TSARINA INPUT

The basic input cards employed with TSARINA are:

CONT	control card
COMM	comment card
DATA	TSAR data card
CW	chemical weapon control card
TSAR	special feature control card
COST	munition and aircraft cost data card
ATTR	attrition rate data card
TGT	target card; one per target
HGT	target height card
PAD	defines special targets in front of aircraft shelter doors
ATT	attack card with attack coordinates;[1] one per weapon delivery pass (or group of identical passes)
ATTI	attack card for use with IAM and multiple aim points per pass
ATTK	attack card with intended target specified
ATT2	alternate attack card
EMD	effective miss distance card; one for each weapon type
UXO	delay and damage data
PATT	submunition pattern card
EQUI	resource equivalence card

[1]Special options permit attacks to be directed at the "MOS," and precomputed impact locations to be entered directly.

MCL	multiple MCL card
SKEW	controls search for a skewed MOS
BAR	mobile arresting barrier card
TEST	controls selective debugging feature
REDO	controls sequential cases
END	terminates overall computation

Several of the basic input cards are supplemented with additional data entry cards that must immediately follow the related basic input card. The CW card is followed by cards that define the coordinates of user-selected monitoring points, and each TGT card is followed by as many cards as are required to specify the resources located at that target. The ATT2 card is actually two cards in sequence, the EMD card may have up to 16[2] supplementary cards, and the PATT card may have up to 16 pairs of supplementary pattern dimension cards. A detailed description of the entries for each type of card is presented in this appendix.

The general arrangement of data on all basic card types is similar; the card name is placed (left-adjusted) in the first four columns and the data are entered in the 11 six-column fields between columns 7 and 72. All data are read with an I6 format, i.e., they are integers, except that, as will be noted from the descriptions defining data entry, two data items are entered in certain fields of the CONT and DATA cards and on the supplementary target cards. Columns 5 and 6 are also used on several cards, as will be described. All fields and subfields are right-adjusted. Furthermore, the name of the target complex being studied and a name for each target may be included in columns 73 through 80 of the CONT and TGT[3] cards, respectively; any alphanumeric names are acceptable.

All linear dimensions should be in feet and the target orientation and the attack heading entries should be in degrees.

[2]The number of supplementary cards for the EMD card may vary with the number of target types being used. Therefore, the user may have up to 16, 33, or 50 supplementary cards when less than 10, 11 to 20, or more than 20 target types are used.

[3]When electronic card images are used, columns 73 through 88 may be used for alphanumeric target names by entering a "1" in column 18 of the CONT card.

CONT

The CONT card controls the mode of operation, the choice of random number generator, the number of trials (attack replications), and output listing options; it also specifies the MCL and MCW for runway attack effectiveness calculations and controls runway repair assessment. This card should be the first card to be entered.

Columns	Data Entry
1–4	CONT
6	If 1, the program computes resource damage levels appropriate for entry into TSAR.
8–9	When 0, the seed for the random number generator is changed from run to run. For any value greater than 0, the seed is the same for all runs; if equal to –1, the random number generator is locked out.
10–12	Number of target types to be entered (maximum of 30).
13–15	Desired number of replications. Default is 1.
16–18	If 1, descriptive data on the cards may extend to column 120, rather than be constrained to an 80-column format.[1]
19–21	Controls printout options as follows: If entry is:

- 8 Terminates execution after initialization.
- 7 Prints special runway crater repair distribution (see concluding note).
- 6 Above, plus condensed trial-by-trial runway crater data (see note).
- 5 Prints multiple trial statistics plus a condensed listing of hits by trial.
- 4 Prints multiple trial statistics plus a condensed listing of runway status by trial.
- 3 Suppresses target listing and prints multiple trial statistics only.
- 2 All above* plus runway results for each trial.
- 1 All above* plus hit summary for each trial.
- –1 All above* plus all hits and target corners.
- –2 All above* plus all impact points.

*except special runway repair data listed with 6 and 7.

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[1]Use of this feature on IBM equipment requires that the user (1) store the input dataset on disk with LRECL = 120, and (2) augment the job JCL so that that dataset will be read on device #8.

23–24 Controls printout options for resource damage:

- 0 No resource damage is listed.
- 1 Damage fraction formatted only for user.
- 2 Damage fraction formatted only for TSAR.
- 3 Both formats.

25–27 When a "1" is entered in column 27, user supplied seeds are read for each trial of each case. This feature permits a user to approximate the statistics of a large set of TSARINA trials with a smaller set of trials for use with TSAR. The necessary seeds are stored on device 16, one seed per card image with an I15 format.

29–30 Normally set to zero; when initialized greater than zero, intermediate computational information is output for program test purposes. If set to greater than 7, the random number generator is locked out.

31–36 MCL for aircraft operations (used to test if the runways are open).

37–42 MCW for aircraft operations (used to test if the runways are open).

45 When the entry is 1, runway results will include the minimum number of craters to be repaired for the runway to meet the MCL and MCW criteria.

48 When the entry is 1, a plot of all impact points will be included for all closed runways (if, also, the printout option entry in column 21 is less than 3); when the entry is 2, impact plots are provided for each runway whether or not it is closed.

49–54 The distance across the runway (INW) that the "minimum runway rectangle" is to be shifted in checking for an adequate section; the default value is 5.

55–60 The distance along the runway (INL) that the "minimum runway rectangle" is to be shifted in checking for an adequate section; the default value is 250.

73–80 A name can be entered here for the entire target complex and it will appear in the heading of the output listing.

When the print control in column 21 is set to 6 or 7, the output includes the cumulative distribution of minimum repairs for each runway and for the airbase as a whole. These distributions are presented as the fraction of trials in which no more than 0, 1, 2, 3, ..., up to 50 crater repairs are required to clear an MOS on each runway and for the airbase overall. If the entry is 6, the trial-by-trial condensed listing available with an entry of 4 is also printed for each trial. These distributions can be especially useful for assisting the user to allocate attacks against an airbase with several runways. When the average number of repairs (i.e., the median number of repairs for the various output repair distributions) differs substantially for the several surfaces, the attack is poorly designed in the sense that the surfaces with the smaller number of repairs should receive larger shares of the overall attack if the minimum repair requirements are to be maximized for the base as a whole.

COMM

The COMMent card places a number of lines of descriptive material at the beginning of the output for each or any case. This card may be placed anywhere in the input stream that a basic card type might appear, but *not* where continuation or supplementary cards are expected. There are no restrictions as to the content and format, except that only the first 80 columns on each line are reproduced. Any number of COMMent cards may appear in any particular case, but the descriptive comments will all appear at the beginning of the output listing; these cards are each executed as they are found in the data stream, before any of the other input data are echoed.

Columns	Data Entry
1–4	COMM
7–12	The number of card images that are to be read and reproduced at the beginning of the case in which this card type is included. It is the user's responsibility to make sure that the number of card images entered immediately after this COMMent card agree with this entry.

DATA

The data card controls the form of the output to TSAR, defines the time and location of the attack, and provides TSARINA the necessary resource identity data for communicating results to TSAR. This card should follow the CONT card.

Columns	Data Entry
1–4	DATA
5–6	If unity, statistical results are punched on cards for subsequent processing and reorganization using auxiliary programs.
12	Enter the number of trials for which damage data, resource loss data, and hit data are to be stored for TSAR.
18	If unity, the multiple-trial damage data for individual targets is suppressed.
24	Number of airbase under attack (as interpreted within TSAR).
29–30	Day of the attack.
31–34	Hour of the attack.
35–36	Minute of the attack.
37–42	Meteorological pattern type. An integer from 1 to 20 that specifies one of twenty environmental patterns (temperature, humidity, and wind speed) to be used in TSAR following the attack. (See CT43/2 in TSAR.) An input of 0 indicates to TSAR that the pattern already in use at the time of the attack should be continued.
44–45	The number of shelters for alert aircraft.
46–48	The target type number assigned to Type #1 aircraft shelters.
50–51	The target type number assigned to Type #2 aircraft shelters.
53–54	The target type number assigned to Type #3 aircraft shelters.
55–57	Minimum clear width for aircraft transit of taxiways (ft).
59–60	Target type number assigned to aircraft taxiways.
61–66	Target type number assigned to aircraft parking ramps.
67–72	Target type number assigned to fuel truck refilling locations.

CW

The CW card controls the use of CW weapons in TSARINA; it specifies the expected wind direction and velocity, and the uncertainty in those estimates, and defines which chemical agents are to be employed. The number of monitoring points that are to be used is also entered with this card, and their locations are given in card images that immediately follow.

Columns	Data Entry
1–4	CW
7–12	Pasquill stability category (1 = C, 2 = D, 3 = E, or 4 = F).
13–18	Temperature (degrees Fahrenheit).
19–24	Atmospheric pressure (Torrs).
25–30	Wind direction (degrees from north). The predicted wind direction at the time of the attack.
31–36	Wind direction uncertainty (degrees). One-half the range of the wind direction distribution, assuming a uniform distribution of wind direction prediction errors.
37–42	Wind speed (mi/hr $\times$ 10). The predicted surface wind speed at the time of the attack.
43–48	Wind speed uncertainty (percent). Assuming a uniform distribution of wind speed prediction errors centered about the predicted wind speed, this entry is equal to one-half the range between the limits.
49–54	Number of monitoring points; when a CW card is to be used following a REDO card, but the monitoring points are not to be changed, set this entry minus.
55–58	Transport velocity from liquid surface films on grass to internal portions of the grass for first agent (cm/min).
59–60	TSARINA agent number of first agent (1 = GB, 2 = GD, 3 = HD, 4 = VX, 6 = BIS).
61–64	Transport velocity from liquid surface films on grass to internal portions of the grass for second agent (cm/min).
65–66	TSARINA agent number of second agent (1 = GB, 2 = GD, 3 = HD, 4 = VX, 6 = BIS).

67–70	Transport velocity from liquid surface films on grass to internal portions of the grass for third agent (cm/min).
71–72	TSARINA agent number of third agent (1 = GB, 2 = GD, 3 = HD, 4 = VX, 6 = BIS).

Following the CW card are supplementary cards giving the coordinates for the number of monitoring points given by the data entry in columns 49–54 of the CW card. The format for the first card is:

Columns	Data Entry
1–6	X-coordinate of the 1st monitoring point (ft).
7–12	Y-coordinate of the 1st monitoring point (ft).
13–18	X-coordinate of the 2nd monitoring point (ft).
19–24	Y-coordinate of the 2nd monitoring point (ft).
.	
.	
.	
49–54	X-coordinate of the 5th monitoring point (ft).
55–60	Y-coordinate of the 5th monitoring point (ft).

The format for the remaining monitoring points (up to a maximum of 100) is identical to that of the first five, allowing five monitoring points per card.

TSAR

Entries on the TSAR card activate certain special features.

Columns	Data Entry
1–4	TSAR
12	A "1" activates a mechanism that introduces *variable* postattack delays in the TSAR simulation. The TSAR model does not simulate the disruptive effects of fires, damaged utilities, damaged roadways, etc.; only the resources most directly affecting the sortie generation process are treated; e.g., aircraft, maintenance personnel and equipment, and aircraft maintenance facilities. To account for the disruptive effects that are not simulated, TSAR permits the user to stipulate that useful activity on the simulated tasks will be delayed by an attack for a user-specified period of time (different values may be entered for aircraft maintenance tasks and civil engineering tasks). This entry provides the user an approximate means for modifying those "postattack disruption delays" in relation to the strength and extent of the attack. Two damage metrics are assessed for each attack: (1) the cumulative MAE against "aircraft in the open" for all reliable weapons; and (2) the fraction of all the targets that are in the TSARINA data base that are at all affected by the attack. (This particular weapon MAE was selected because it seemed an appropriate single choice to provide the needed damage proxy.) The product of these numbers (suitable normalized) is then transferred to TSAR where the user-specified nominal delay times are multiplied by this factor. The normalization is such that a cumulative MAE of 10 million square feet and damage to 20 percent of the TSARINA target set produces the nominal delay; i.e., Delay = (Nominal Delay) × (Total MAE/10**7) × (Percent Targets Affected/20)
18	Coordinates of all weapon locations are stored on device 12 when a "1" is entered. This data set may be used for subsequent graphic display (or reentered into TSARINA using the special ATT card option.
24	Entries in this field limit the target data listed with the input data. A "1" suppresses target data for "pads"; a "2" suppresses the data for pads and aircraft shelters; a "3" suppresses data for pads, shelters, and the taxiway arcs; and a "4" suppresses the data for taxiway arcs only.

30	An entry in this field suppresses the EMD card data from the listing of input data.
36	Entries in this field suppress the hit data summaries for certain target types after each trial, but not from the multiple-trial hit summaries. The target types suppressed are the same as outlined for the column 24 entry.
42	When this field is initialized to "1," the mean areas of effectiveness that are implied by the EMD data for point-impact weapons are computed and listed after the input data.
48	When this field is initialized, the resource data entered on the special supplementary TGT cards will not be echoed in the output.
54	When this field is initialized, the unit cost data provided with the COST cards is used to estimate the cumulative campaign costs for munitions and the expected aircraft losses; these costs are listed for each case. If this entry is negative, the costs will be estimated without carrying out the attack computations to provide a preliminary check on projected costs.
55–60	When a maximum campaign cost is specified in this field (in tenths of millions), any attacks (entered with the several ATT type cards) that would exceed this limit are omitted from the campaign.

COST

The COST card collects expected campaign costs for TSARINA attacks, and, if desired, terminates a TSARINA run when a specified cost is exceeded. Campaign costs are defined as the cost of the expended munitions, plus the cost of the expected aircraft losses. The expected aircraft losses are based on the survival probability specified with the ATT type cards, or, when they are provided, on the sortie attrition rates specified by weapon and day with the ATTR cards. This costing capability is controlled by the DOCOST entry in the eighth data field of the TSAR card; if the campaign is to be limited to some particular cost, that limit is specified in the ninth field of the TSAR card.

A COST card is used to enter the cost of each type of munition, and the costs of the aircraft that are to carry that munition. The TSAR card, and all COST cards, must be entered before any ATT, ATT2, ATTI, or ATTK cards are entered. The format for this card is as follows:

Columns	Data Entry
1–4	COST
5–6	Munition type.
7–12	Cost of an individual munition, in thousands of dollars.
13–14	Number of these munitions that are carried.
15–18	Cost, in tenths of millions, of the aircarft that carries the number of munitions just specified.
19–20	Number of these munitions carried by another MDS.
21–24	Cost of this second aircraft type.

Up to 10 pairs of munitions loadings and aircraft types may be specified in columns 13 through 72. The munitions loading is used to distinguish aircraft type since that information does not exist in the database. To function correctly, *no two aircraft types may carry the same number of munitions* in any TSARINA run.

The campaign costs are incremented as each ATT card is read, and the cumulative campaign costs are printed at the beginning of each case. If a maximum cost has been specified on the TSAR card, all attacks that exceed that cost will be cancelled; a separate message is printed for each attack cancelled, and a special message is also printed if one or more complete cases must be cancelled because of cost.

ATTR

The ATTRition card provides the user an alternate, and more convenient, way of specifying the attrition rate for each type of delivery vehicle, than by using the entries on the several types of ATT cards. This option specifies the expected attrition rate for the delivery tactics used with each type of munition and for each of up to 30 days of an attack campaign. It also specifies attrition rates in tenths of percent.

The only entries on the ATTR card are the weapon type and the number of supplementary cards that will be used to specify attrition rates: one or two. For a given TSARINA scenario (run), only one type of aircraft may be used to deliver a particular type of munition, since aircraft type as well as delivery tactic is implied by weapon type on this card. The format for the basic card is:

Columns	Data Entry
1–4	ATTR
7–12	Number of munition type.
13–18	Number of supplementary cards to be used to enter the day-to-day attrition rates: enter "1" for 1 to 15 days, and "2" for 16 to 30 days.

The format for these supplementary cards is 15I4; attrition rates must be entered for each day for which these rates will be needed in the scenario. The entries are in tenths of percent; e.g., "36" for an attrition rate of 3.6 percent.

TGT

Each TGT card designates the location, size, and orientation of a rectangular target. When TSARINA results are to be used as inputs to TSAR it is essential that the data in columns 51–54 be consistent with the TSAR data base.

Columns	Data Entry
1–3	TGT
7–12	The X-coordinate of the westernmost corner of the target. If the westernmost corner of any target does not fall in the first quadrant of the X-Y coordinate system, TSARINA automatically translates the origin (a multiple of 1000 feet) so that all targets are in the first quadrant. If after translation, targets do not fall within the allowed 32000 × 32000 area, they are "moved" to the edge of that area and the user is notified.
13–18	The Y-coordinate of the westernmost corner of the target. If a target boundary runs exactly north-south, the X and Y coordinates of the southwestern corner should be specified.
19–24	Target dimension along the boundary running northeast (or north) from the reference corner specified in the two previous fields.
25–30	Target dimension along the boundary running southeast (or east) from the reference corner.
32	Number denoting the side of an aircraft shelter that has a PAD: "1" denotes the side running northeast (north) from the westernmost corner; the other sides are numbered clockwise from number 1. This field should be specified only for aircraft shelters, and only when a "PAD" card is used.
33–36	Heading in degrees of the northeast (or north) heading boundary of the target (along the dimension specified in columns 19–24).
41–42	Target type. Targets may be grouped into up to 30 different vulnerability categories. This entry is used in conjunction with the effective miss distance on the EMD card. Target Type #1 is restricted to runways and taxiways that may be used for flight operations—there can be at most MXRWY targets of this type. The user may specify other target types as aircraft parking ramps, taxiways, and aircraft shelters; if used with TSAR, the target type number selected to designate each of these target types must be entered on the DATA card. For all other targets, structures with similar construction and materiel vulnerability can be assigned a common target type number; if additional stratification in results is desired, targets of similar construction but different materiel vulnerability may be grouped under two or more target types.

48	If greater than zero, all hit locations will be printed when the entry in column 21 of the CONT card is zero or less.
49–54	Facility number used in TSAR; only to be used when the results are to be transferred to TSAR. No entry is permitted for aircraft shelters, parking ramps, or taxiways except that the runway number should be entered for each of the taxiway segments that constitute a runway.
55–60	Class of resource stored in the facility, if storage is restricted to 100 percent of one resource class, or to 100 percent of one type of one resource class.
61–66	Type of resource, if only one type is stored in the facility (all types are inferred if blank or zero).
67–70	Number of subsequent cards used to describe the types and quantities of resources stored in this facility (use only when columns 55–66 are blank).
73–80	Alphanumeric target descriptors; the entry in columns 73–78, if unique, can be used on ATTK cards to designate the intended aim point. Columns 73–120 may be used if input is not restricted to 80 columns (see column 18 on the CONT card).

In some instances, several functions are collocated in a single facility on an airbase—especially distributed elements of two or more shops. If this situation is to be simulated, and if facility repair work is not to be required in TSAR for each of the facilities (which are in fact the identical buildings), TSAR must be informed of this special geometric relationship. A special record is prepared and transferred to TSAR whenever (1) two or more TGT cards in sequence each specify an aircraft shelter or have a TSAR facility number (columns 49–54) and (2) each have the identical size, location, and orientation. If one of these identically located facilities is an aircraft shelter, it must appear first. TSAR facility repair data should be specified only for the first "facility" in each such sequence.

SUPPLEMENTARY TARGET CARDS

Each TGT card may be followed by as many supplementary cards as are necessary to define the resources that are located in that particular target. Each of these cards is read with a 5X, 5(3X,I2,I5,F5.0) format that provides for five entries of resource class, resource type, and percentage at the target. Entry of the letter "C" (for class), preceding the resource class (in columns 7, 22, 37, 52, and 67), to identify the supplementary target cards has been found helpful in reviewing the large data sets required to represent a complex airbase (see Figs. 11, 12, and 13).

Columns	Data Entry
9–10 24–25 39–40 54–55 69–70	Number identifying the resource class: 1 Personnel 5 TRAP 2 AGE and equipment 6 Building materials 3 Aircraft parts 7 POL 4 Munitions
11–15 26–30 41–45 56–60 71–75	Number identifying which type of the specified resource class is located here.[1] If there is no entry for "type," all types of the specified class (that have not otherwise been specified) are assumed to be present.
16–20 31–35 46–50 61–65 76–80	Percentage of the base stocks of the specified type and class of resource that are located in this target. Whole numbers are interpreted as percentages; a decimal entry is required to specify tenths of a percent. The output listing of resource storage data is in tenths of percent; e.g., 273 implies 27.3 percent.

[1]The number "1000" added to a personnel designation specifies off-duty personnel, and "100" added to a munitions designator specifies weapons that are not assembled.

HGT

The HGT card permits the user to specify the vertical height for each of the different target types. When a height has been specified, and the impact angle of a point-impact weapon is not vertical, these data permit TSARINA to assess direct hits not only for weapons that would hit the ground plane within the target outline but also when the weapon would intersect the target box.

Columns	Data Entry
1–3	HGT
6	Card number: #1 for target types #1 to #10; #2 for target types #11 to #20; #3 for target types #21 to #30.
7–12	Target height of target type #1, #11, or #21.
13–18	Target height of target type #2, #12, or #22.
.	
.	
.	
61–66	Target height of target type #10, #20, or #30.

PAD

The PAD card allows the user to generate a parking area (pad) in front of each aircraft shelter door with minimum effort; these new "targets" are then used to provide a more realistic estimate of damage to the shelter doors and shelter contents. Each of the three types of shelters can have a distinct size pad. Hits on these areas increase the damage to the shelter above that assessed for misses near the sides and the rear; they also increase the damage estimates for resources within the shelter *when the shelter door is open.*

The creation of "pads" requires that the user (1) designate the target type to be assigned to these pads and specify their dimensions on the PAD card (*which must be entered before the TGT cards*) and (2) designate on which "edge" of each aircraft shelter rectangle the shelter door is located. The door location is noted in column 32 on the TGT card of each aircraft shelter with a number from 1 to 4: "1" denotes that the door is on the side running northeast (or north) from the southwesternmost corner of the shelter; the other sides are numbered clockwise around the shelter from #1. The entries for the PAD target types on the EMD cards are unique to this application.

Columns	Data Entry	
1–3	PAD	
11–12	Number designating the target type for pads in front of the door at the Type #1 aircraft shelters	
13–18	Dimension of the pads measured outward from Type #1 aircraft shelter doors	
19–24	Width of the pad at Type #1 aircraft shelters	
29–30	Number	
31–36	Dimensions	Same for Type #2 shelters
37–42	Width	
47–48	Number	
49–54	Dimensions	Same for Type #3 shelters
55–60	Width	

ATT

The ATT card specifies the parameters of each weapon-delivery pass relative to the coordinates of the desired mean point of impact (DMPI). Inputs required are the attack heading (measured from north in the coordinate system used to specify the targets), the DMPI coordinates for a single weapon or for the middle of a stick of weapons, the aiming error expressed as REP and DEP, the ballistic error of the individual weapons, the number of weapons to be delivered in the pass, the stick length, the weapon type, and the probability of arrival at the target. For CW weapons only, the altitude of the burst of the weapon is also required.

Columns	Data Entry
1–3	ATT
5–6	Total number of passes with identical characteristics; default = 1.
8–10	Attack heading; degrees from north.
11–12	Heading uncertainty, in degrees.
13–18	The X-coordinate of the DMPI of a single weapon or the middle of a stick of weapons.
19–24	The Y-coordinate of the DMPI as above.
25–30	The REP in feet.
31–36	The DEP in feet.
37–42	Ballistic dispersion in range of individual weapons in feet (R-DISP).
43–48	Ballistic dispersion in range of individual weapons in feet (D-DISP). Default value is R-DISP.
49–54	The number of weapons in the stick.
55–60	The length of the stick (the distance between the first and last weapons of the stick in the absence of dispersion).
61–64	The burst altitude (ft/10) for chemical weapons; for point impact weapons, a –1 in this field specifies that this attack is to be assumed to be directed at the MOS determined after prior attacks.
65–66	The weapon type (provides reference to the appropriate effectiveness data). An entry is required (an integer from 1 to MXWPN); otherwise hits will not be recorded.
68–69	Inclination angle at impact; degrees off vertical.
70–72	Probability of arrival at target (× 100); default = 100.

SPECIAL ATT CARD OPTIONS

Subsequent Attacks on the "MOS"

This option permits the user to specify that certain of the ATT cards for a TSARINA attack are to be directed against the flight surface that has most recently been chosen in TSAR as the minimum operating surface, i.e., the MOS. The use of this feature implies that the attacker has obtained evidence by which he is able to decide which part of which flight surface his enemy has chosen to clear for the MOS, and to direct his attack (or a part of it) at that particular section of the surface. Naturally, this option is meaningful only when TSARINA is used in conjunction with TSAR, where the effects of a sequence of attacks is treated.

To activate this feature, the user need only mark a TSARINA ATT card (that specifies cratering weapons) with a "-1" in columns 63–64, and select the DMPI for that ATT card on the assumption that the MOS is centered at X = Y = 20000, and that the MOS runs east-west. All hits between Y = 19850 and 20150 are saved and transmitted to TSAR, where they are centered on the MOS from the prior attack. Since the actual impact points are not known until defined in TSAR at the time of the attack, no collateral damage can be assessed for these weapons.

Use of Precomputed Weapon Impact Locations

To accommodate special circumstances, TSARINA provides a means by which the coordinates of weapons may be entered directly, rather than computed from delivery errors, dispersion, etc. To use this feature, the *first* ATT card for the case in which it is desired to use this feature *must* have the value –32000 entered as the X-coordinate of the desired mean point of impact (i.e., in columns 13–18), and the attack type (ATTYPE, Ref. [5]) in column 24. When this entry is encountered during execution, the program will read impact data from device 14 until the value –32000 is encountered as the X-coordinate for a weapon. The format for the data read by device 14 must be 6I6, and the entry data in the six fields are: (1) X-coordinate of the weapon, (2) Y-coordinate, (3) weapon type, (4) "1" for a UXO, (5) the attack heading in degrees, and (6) the burst altitude of chemical weapons in feet. (Data from one TSARINA run will be generated in this format, for use in subsequent TSARINA runs, by use of the special feature controlled from column 18 on the TSAR card). For dispenser weapons, the "weapon coordinates" are interpreted as the location of the dispenser centroid, or as the chemical weapon burst point. Other ATT cards may be entered after this special ATT card if the user wishes to simulate additional attacks.

Data may be entered with this special ATT card option for a sequence of attacks, but the option is *only functional for a single trial.*

ATTI

This special card permits the user to represent inertially aided munitions (IAM) in TSARINA simulations. These are munitions that would be launched by an attacker with an intended impact point specified for each weapon. Their position at launch would be determined by the delivery vehicle with GPS (Global Positioning System) (or an equivalent position locating system); the weapon would adjust its ballistic trajectory such as to impact the intended target. One attacker could deliver (drop or toss) several such weapons to each of several specific points; for example, to several aircraft shelters, or on a line crossing the runway.

When this type of weapon is to be used, the attack is defined with an ATTI card, and either one or two supplementary cards. Although similar to an ATT card, the DMPI is not specified on the ATTI card. Rather, supplementary cards are required to designate the targets. There are two options: If a "1" is entered in columns 55–64 of the ATTI card, up to 12 "target designators" may be entered in 12 six-column fields on one supplementary card. A "target designator" is the literal that appears in columns 73–78 on the relevant TGT card, as explained more fully in connection with the ATTK card. If a "2" is entered in columns 55–64 on the ATTI card, two supplementary cards are required: The first lists the desired X-coordinates for up to 12 IAM weapons (in 12 six-column fields); the second lists the Y-coordinates. The entries in columns 1–54 and 65–72 of the ATTI card are interpreted identically with those on the ATT card, except that the REP and DEP pertain to the errors of each delivery vehicle's positioning system. The systematic map errors, or target location errors (TLE) that affect all attackers equally, are specified with the TLE card, explained below. Each IAM weapon is affected by the vehicle's positioning errors, the dispersion, and the TLEs, and, when submunitions are involved, by the submunition's dispersion specified on the PATTern card.

Columns	**Data Entry**
1–4	ATTI
5–6	Total number of passes with identical characteristics; default = 1.
8–10	Attack heading; degrees from north. Only affects dispersion orientation.
11–12	Heading uncertainty, in degrees.

25–30	The REP of the aircraft's positioning system.
31–36	The DEP of the aircraft's positioning system.
37–42	The dispersion in range for an IAM (or of the centroid of a submunition pattern).
43–48	The dispersion in deflection for an IAM.
49–54	Number of IAM weapons delivered by the attacker (max. 12).
55–60	Enter "1" if "target designators" are to be entered; "2" if target coordinates are to be entered. Default = 1.
65–66	The weapon type.
68–69	Inclination angle at impact; degrees off vertical.
70–72	Probability the delivery vehicle arrives at target (× 100); default = 100.

Either the "target designator," or the X and Y coordinates, of the intended aimpoints for each of the IAM weapons, are specified on supplementary cards; up to 12 locations can be specified. "Designators" or coordinates are entered into 6-column fields.

TLE

The impact locations of inertially aided munitions may be affected by map errors—basic uncertainties as to where targets are located in the attacker's global coordinate system—as well as by other errors. Target location errors (TLE) affect all attacks equally. The standard deviation of the TLE errors are specified with this card. (In those instances in which the user uses the multiple-target feature of the ATTI card for weapons without TLEs, those weapon-type numbers should be entered on the TLE card as noted below.)

Columns	Data Entry
1–3	TLE
7–12	The standard deviation of the TLE in the X-coordinate.
13–18	The standard deviation of the TLE in the Y-coordinate.
19–24 . . 43–48	The weapon-type number of weapons for which the TLE should *not* be applied (up to five types in 6-column fields).

ATTK

The ATTK card permits the user to specify a target as the intended aim point, rather than by specifying an aim point's coordinates, as on the ATT card. The format for the ATTK card is identical with that for the ATT card except for the entries in columns 13–18 and 19–24, and an additional entry in columns 74–76. With these exceptions, which will be explained, the attack is handled in just the same way for the ATTK card as for the ATT card.

The difference with the ATTK card is that a "target designator" is specified rather than the X-coordinate of the aim point in columns 13–18. The center of the designated target is computed, and this is taken as the aim point for the attack. If another "target designator" is specified in columns 19–24, the center of that target will be selected as the aim point for some percentage of the trials. The percent of the time that this second target is to be selected is entered in columns 74–76 of the ATTK card. This optional target feature has been included as a means of at least crudely reflecting a pilot's distraction due to camouflage, concealment, and deception (CCD) measures.

If the target designator specified in columns 13–18 and in columns 19–24 are identical, the attackers all select the same aim point but one group of attackers has a different dispersion than the other. This feature permits the user to assess PGMs using the two-circular error probable (CEP) method outlined in the JMEM Basic Manual. The fraction of the attackers specified in columns 74–76 have the dispersion specified on the basic ATTK card, and the remainder have the dispersion entered in columns 37–42 and 43–48 of a supplementary card entered immediately following the ATTK card. With the REP = DEP = 0, the two sets of dispersion data provide the two-CEP representation.

The "target designators" specified on the ATTK card must correspond *exactly* to whatever alphanumeric description of the target has been specified in columns 73–78 of the appropriate TGT card. Columns 73–80 of the TGT card may still be used for a description of the target, but the first six characters must be unique if they are to be specified on an ATTK card. Normally, this 6-column field will contain the actual facility number; if such numbers are not available, or if a different set of numbers are desired, for whatever reason, it must be remembered that the data in columns 73–78 must be referred to as the "target designator" on the ATTK card.

ATT2

The ATT2 card should be used in place of the ATT card when the user wishes assistance with trajectory calculations. With this card, the user expresses the attack in terms of speed, altitude, dive angle, intervalometer settings, etc., and a special subroutine converts these inputs to those demanded on the ATT card. The conversion procedure is the JMEM/AS Open-End Method Zero as outlined in [17].

Both ATT and ATT2 type cards may be used in the same run; the order of entry is of no importance. When ATT2 cards are used, the input data will be reproduced as submitted, as well as being tabulated in the normal manner, after conversion.

Data input with the ATT2 procedure requires two cards. The first card is labeled ATT2 in the first four columns and has input similar to that on an ATT card (all fields are read with an I6 format); a second unlabeled card is mandatory following each ATT2 card. The format for both cards follows. When these cards are used, all linear dimensions in the input data must be in feet.

Columns	**Data Entry**
1–4	ATT2
5–6	Total number of passes with identical characteristics; default = 1.
8–10	Attack heading in degrees from north.
11–12	Heading uncertainty, in degrees.
13–18	The X-coordinate of the DMPI of a single weapon or the middle of a stick of weapons.
19–24	The Y-coordinate of the DMPI as above.
25–30	The CEP in the normal plane in mils, or, if DEP is specified, a constant that, when divided by the sine of the impact angle, gives the REP in mils.
31–36	The DEP in mils (if omitted, CEP controls).
37–42	Ballistic dispersion in mils.
43–48	Blank.
49–54	The number of weapons in the stick.
55–60	Blank.
61–64	Burst altitude (ft/10) for chemical weapons.

65–66	The weapon type.
67–72	Probability of arrival at target; default = 100.

The data format for the second card of each ATT2 pair is as noted below (this card is used with a 6X, 9I6 format). Typical ballistic data required for this card are noted in Table A.1.

Columns	**Data Entry**
7–12	Aircraft velocity (kn).
13–18	Release altitude of last bomb (ft).
19–24	Dive angle at release (deg).
25–30	Terminal velocity of a low-drag weapon, or the first leg of a high-drag bomb (ft/sec) (see Table A.1) (VT1 in JMEM).[1]
31–36	Terminal velocity of a cluster bomblet or a high-drag bomb (ft/sec) (see Table A.1) (VT2 in JMEM).
37–42	Probable error in estimating and correcting for wind effects (ft/sec).
43–48	Cluster opening time or fin opening time for a high-drag bomb (msec) (TD in JMEM).
49–54	Intervalometer setting (msec).
55–60	Dispenser intervalometer setting (msec).

[1]Illustrative values are noted in Table A.1.

Table A.1

TYPICAL BALLISTIC PARAMETERS

Weapon	VT1 (fps)	VT2 (fps)	T or H
Mk-81 Mod 1	1850	0	0
Mk-81 SE	1100	208	300 msec
Mk-82 Mod 1	1900	0	0
Mk-82 SE	1200	240	350 msec
MK-83	2250	0	0
MK-84	2850	0	0
M-117 Unretarded	1950	0	0
M-117 Retarded	900	168	300 msec
M-118	2450	0	0
AN-M64A1	1600	0	0
AN-M65A1	2000	0	0
Mk-36 DST	1200	0	350 msec
CBU-38	450	0	0
CBU-52B/B	1000	230	Variable altitude (ft)
CBU-58/B	950	215	Variable altitude (ft)

SOURCE: Ref. [17].

EMD

Point-Impact Weapons

The EMD and supplementary cards provide information regarding weapon effectiveness against the several types of targets and several classes of resources for each weapon type. The formats of the entries differ for point-impact weapons, cluster munition dispensers, and chemical weapons. As will be noted, one may also represent weapons that dispense point-impact weapons as well as a cluster of small submunitions or mines. The entries for aircraft shelters have a special interpretation. The format for point-impact weapons was illustrated in Fig. 3.

Each type of point-impact weapon will be represented by up to 17 cards (or 34 (51) cards, if 11–20 (21–30) target types are specified on the CONT card), although just the first card, the EMD card, could suffice for certain limited assessments. For point-impact weapons (GP bombs, PGMs, BKEPs, UXO, etc.) the entries on the EMD card are:

Columns	Data Entry
1–3	EMD
5–6	Enter the total number of cards (this card plus supplementary cards) that are associated with this type of weapon.
8–9	Weapon type number.
10–12	Weapon reliability (percentage).
13–18	R1 Radius of effectiveness versus target type #1.
19–24	R1 Radius of effectiveness versus target type #2.
.	
.	
.	
67–72	R1 Radius of effectiveness versus target type #10.

The supplementary data for the several target types are located in the corresponding fields on the cards that immediately follow the first card. The entries on cards 2 to 8 apply to near misses, and the entries on cards 10 to 17 apply to direct hits; if there are *no* entries on cards 10 to 17, the entries on cards 1 to 8 apply to direct hits and near misses. Definitions of the data to be entered on the EMD card and on the supplementary cards are noted below; somewhat different definitions apply for the target types that the user has designated as taxiway and ramps and as aircraft shelters, as will be outlined shortly.

Card No.		All Target Types (except shelters)
1	10	R1 Effective radius against target type.
2	11	R2 Secondary effects radius.
3	12	Personnel loss criteria.
4	13	AGE loss criteria.
5	14	Spare parts loss criteria, or aircraft damage criteria for taxiways and ramps.
6	15	Munitions (and POL) loss criteria, or aircraft kill criteria for taxiways and ramps.
7	16	TRAP loss criteria.
8	17	Building materials loss criteria.
9		Flag - Controls loss criteria interpretation.

When some fraction of the reliable point-impact weapons is to be assumed to not explode, but to be counted as UXO, that percentage should be entered in columns 6–8 of the first supplementary card. When this is done, the numbers of UXO that impact within a specified distance (entered in columns 9–12 on that card) of each taxiway segment[1] are counted for transfer to TSAR. For TSAR to simulate the subsequent detonation of a UXO, and to assess the casualties among personnel working on the flight surfaces or near the explosion, it is also necessary to enter a UXO card for the weapon. If all weapons that do not explode on impact are to be treated as UXO, the weapon reliability should be entered as 100 on the first EMD card. If the point-impact weapon(s) is accompanied by a cluster of submunitions or mines, the weapon number that defines the cluster is entered in columns 3–4 of the first supplementary card.

The data on cards 1 to 8 apply in the case of a near miss and those on cards 10 to 17 apply for a direct hit. If no data are entered for a direct hit, the near miss inputs are used; if any data are entered for a direct hit on a particular target type, only the values on the 10th through 17th cards are used. Null entries are interpreted as zero.

---

[1]If an UXO is within the specified distance of two or more taxiway segments, it is associated with the first segment encountered during processing.

For target types that the user has designated as taxiways and aircraft parking ramps, the 5th (14th) and 6th (15th) card entries are interpreted as the criteria for damage and kill, respectively, of aircraft located on these types of targets.

If the vulnerability of a specific target type to direct hits is especially sensitive to impact angle of a certain type of point-impact weapon, one might wish to define a distinct EMD data set for each of several impact angles and associate a distinct weapon type with each of several different delivery conditions (i.e., impact angles).

If 11 to 20 (21 to 30) target types are treated, a second (and third) set of (up to 17) cards should be placed immediately after the first set described above; these cards are each read with a 12X, 10I6 format.

The eight weapon effectiveness options that may be specified as the loss criteria for the six resource classes are defined below; they are illustrated in Fig. A.1.

FLAG

0	Ignore this class of resource.
1	Value represents the probabliity of kill within a circle of radius R1.
2	Value represents probability of kill of the resources within a circle of radius R2.
3	As in 2, given that radius R1 intersects the target perimeter.
4	Value is the radius of kill R of these resources (i.e., P_k = 1.0).
5	Value is the radius of kill R of these resources, given that radius R1 intersects the target perimeter (i.e., P_k = 1.0).

The last three options are defined with a combination of a radius and a probability of kill.

6	Value is 1000 times the radius R—of an area within which the PK is one-fourth that value of PK within R1—plus the value of PK within R1 (thus 60080, for example, specifies that PK is 0.80 within R1, and 0.20 in the annular area between R1 and 60 feet).
7	Value is 1000 times the radius R—of an area within which the PK is one-fourth that value of PK within R2—plus the value of PK within R2.
8	As in 7, given that radius R1 intersects the target perimeter.

These criteria are specified for each target by the value of the FLAGs on card 9. Thus, FLAG = 321475 would imply that the six classes of resources are to be assessed by options 3, 2, 1, 4, 7, and 5, respectively, for the particular weapon type and target type for which it is listed.

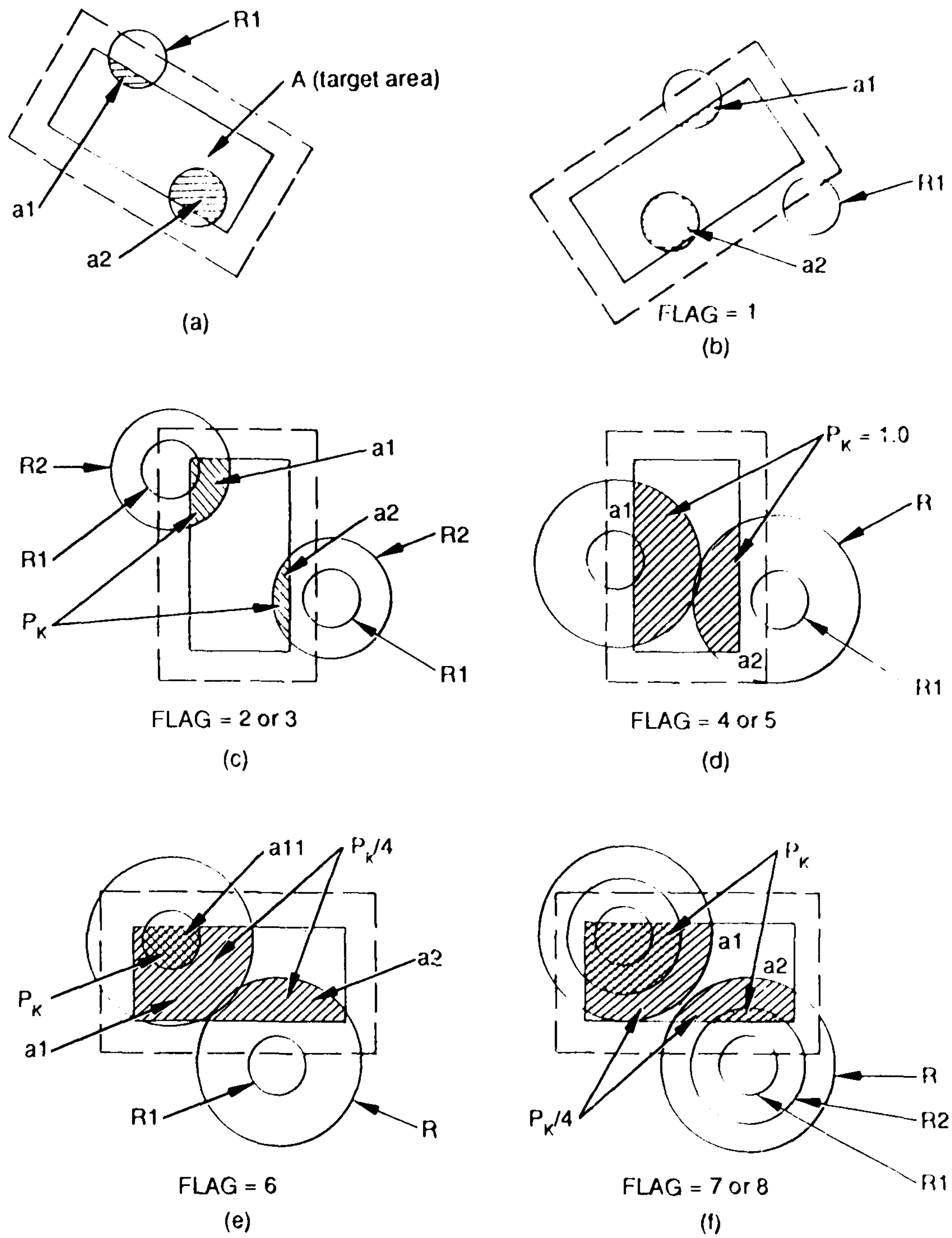

Fig. A.1—Illustrations of optional loss criteria

Compound Weapons

Weapons that dispense two types of submunitions, such as the JP-233, MW-1, and the DAACM, can also be represented with TSARINA. Typically, this type of weapon dispenses a pattern of point-impact submunitions, such as BKEPs, and a pattern of mines. To represent this type of munition, the weapon type of the mine cluster is specified in columns 3-4 on the first EMD supplementary card for the point-impact weapon.

If the center of the mine cluster is displaced X feet downrange from the center of the first pattern, X is specified in columns 37–42 on the EMD card for the mine cluster.

This "compound weapon" feature may be used with several weapon combinations:

1) A point-impact pattern	2) A mine pattern
1) A mine pattern	2) A different mine pattern
1) A point-impact pattern	2) A CW weapon
1) A mine pattern	2) A CW weapon

Only these combinations may be used, and *only* in the order specified. A third weapon type may *not* be compounded to the first two types.

Aircraft Shelters

The use of point-impact weapon EMD cards is somewhat different for aircraft shelters. The 2nd through 9th cards are interpreted the same as for any other target type, but the other entries, noted below, are defined as follows:

Card No.	Data Entry
1	R1 effective radius against aircraft in shelters with closed doors.
10	R3 effective radius against aircraft in shelters with open doors.
11	Effective weapon radius for shelter damage; the shelter damage is estimated as the percentage of the shelter area covered by a circle with this radius, as modified by the entry on the 17th card (see below).
12	Probability of aircraft damage in a shelter with a closed door, when a weapon fails within a radius of R1 from the shelter.
13	Probability of aircraft damage in a shelter with an open door, when a weapon fails within a radius of R3 from the shelter.
14	Probability of irreparable aircraft damage in a shelter with a closed door, when a weapon falls within a radius of R1 from the shelter.

15	Probability of irreparable aircraft damage in a shelter with an open door, when a weapon falls within a radius of R3 from the shelter.
16	Probability the aircraft shelter is killed when a weapon hits within a radius of R1 from the shelter.
17	Shelter damage modifier (see below).

Additional Damage for Aircraft Shelters Using the PAD Card

When a PAD card is used, damage and destruction of *aircraft* in a *closed* shelter is determined as just described, but the probability of damage or destruction of aircraft in *open* shelters is determined as the likelihood that the aircraft does not survive the effects specified on the EMD cards for shelters, and does not survive the weapon effects specified on the 6th and 7th cards (for aircraft damage and kill, respectively) of the PAD EMD data.

Shelter damage is determined as the combination of two distinct damage effects: (1) a damage percentage based on the shelter's nominal vulnerability for a weapon that lands on or adjacent to the shelter, and (2) an *additional* damage percentage that is associated with weapons that land in front of the shelter on the user-designated pad. This second component of shelter damage provides a mechanism to reflect the ofttimes greater probability of shelter door damage for weapons that strike adjacent to the door. The two damage fractions, D1 and D2, are combined assuming independence, i.e., $D = 1 - (1 - D1) \times (1 - D2)$.

The first shelter damage component is estimated as the fraction of the shelter area that would be covered by a circle (of the radius specified on the 11th EMD card for shelters) drawn about the weapon's impact point, multiplied by the percentage specified on the 17th EMD card; if not specified, this latter value has a default of 100 percent. The second shelter damage percentage is computed with the data on the 8th PAD EMD card following the normal TSARINA rules for computing damage using the FLAG value.

When the PAD card is used, damage to the personnel, equipment, and parts in a *closed* shelter is assessed on the basis of the weapon effects listed for shelter type targets, as described above; for an *open* shelter, damage to those contents is augmented on the basis of the weapon effects specified on the 3rd through 5th EMD cards for the PAD target types (and defined by the FLAG on the 9th card). Damage to "parts" is used to reduce the fraction of parts that can be salvaged (FSALVG) from an aircraft that is killed during an attack.

EMD

Dispenser Munitions

CBUs dispense small contact-activated bomblets over a substantial area; other dispensers can be used to release small antipersonnel and/or antimateriel mines in similar patterns. Several such dispensers can be released by an aircraft in a single pass over a target area, much like a stick of bombs. Formats used to define these types of munitions are described here; the patterns are all approximated as rectangles, (normally) centered on the computed impact points, that have uniform properties.

Columns	Data Entry
1–3	EMD
5–6	Enter the total number of cards (maximum = 8) that are associated with the first ten target types for this type of weapon.
8–9	Weapon type.
10–12	Weapon reliability (percent).
13–18	Enter the downrange length of the rectangular pattern as a negative entry.
19–24	Enter the crossrange width of the rectangular pattern (as a positive entry).
25–30	When some or all of the dispensed munitions are mines, enter the total number of mines per dispenser.
31–36	When mines are included, enter diameter of the area influenced by a mine.
37–42	Enter the distance that the center of the rectangular pattern is translated downrange from the computed impact point.

The last entry is intended to be used when a cluster is combined with point-impact weapons, and permits the center of the cluster to be displaced from the center of the impact weapon pattern.

The supplementary cards for dispenser munitions permit the user to specify the expected percentage loss of various classes of resources when they are within the CBU bomblet pattern. The first supplementary card is blank and up to six additional supplementary cards can be used with entries defined as follows:

Columns	Data Entry
13–18	Expected percentage loss at #1 type targets.
19–24	Expected percentage loss at #2 type targets.
.	
.	
.	
67–72	Expected percentage loss at #10 type targets.

These cards are organized similarly to those for point-impact weapons; that is, the 3rd through 8th cards apply to personnel, AGE and equipment, spare parts, munitions (or POL), TRAP, and building materials, respectively, except for the target types specified as taxiways and ramps. For these latter target types, the entries on the 5th and 6th cards are interpreted as the probability that an aircraft is damaged and the probability that an aircraft will not be reparable. The average aircraft damage and kill rates for the taxiways and ramps are transferred to TSAR at attack time; these rates for the ramps are applied to whichever aircraft are assigned to the particular ramps at attack time.

If there are more than 10 types of targets, only the expected loss rate cards should be entered for the six resource classes; i.e., if the entry in columns 5–6 on the EMD card is 6, and there are between 11 and 20 (21 and 30) target types, a total of 10 (14) cards would be required.

For dispensers that contain only mines, only the basic EMD card is required.

EMD

Chemical Weapons

For chemical weapons, the EMD and supplementary cards contain data values defining the agent type and surface deposition pattern of the weapon; no data related to effectiveness are included. The surface deposition pattern is represented by (up to 17) rectangular (or elliptical) layers over which the surface deposition is constant. The total surface deposition pattern is the sum of the values from each layer.

Columns	Data Entry
1–4	EMD
5–6	The number of layers representing the pattern.
8–9	Weapon type number.
10–12	Weapon reliability (percent).
17–18	–1 (this specific entry identifies the weapon type as a chemical munition).
19–24	Downwind dimension of the first layer (ft).
25–30	Crosswind dimension of the first layer (ft).
31–36	Downwind offset of the first layer (ft).
37–42	Crosswind offset of the first layer (ft).
43–48	Surface wind speed for the pattern (mi/hr × 10).
49–54	Agent surface concentration for the first layer (mg/m^2).
55–60	Agent droplet mass median diameter for upwind half of the first layer (microns).
61–66	Agent droplet mass median diameter for downwind half of the first layer (microns).
69	TSARINA agent number (1 = GB, 2 = GD, 3 = HD, 4 = VX, 6 = BIS).
70–72	Spread factor × 100 (ratio of droplet diameter on the ground to droplet diameter considered as a sphere).

Following the EMD card for a chemical weapon are cards giving the data values for the remaining layers of the pattern. The format for each of these cards is identical to the EMD card from columns 19–72; columns 1–18 are not used.

A "1" or "–1" in columns 7–8 of the first supplementary card activate one of two special features. If a "1" is entered, the chemical patterns are assumed to be generated by a spray tank on a delivery aircraft, and the "crosswind" dimension is interpreted as a length parallel to the aircraft path; if the aircraft heading is not at 90° to the wind direction, the resultant patterns are parallelograms rather than rectangles.

If a "-1" is entered in columns 7–8 on the first supplementary card, the shape of all CW patterns is assumed to be elliptical, with maximum dimensions as entered in columns 19–24 and 25–30. As with the rectangular representation, the intensity is assumed uniform within the ellipse.

UXO

The UXO card permits the user to define the time delays that are appropriate before a UXO detonates, and the casualty rates that should be applied to UXO removal teams, or other civil engineering personnel and equipment, working at or near the explosion. Each UXO card provides the data for the one type of weapon.

In TSAR, UXOs are presumed to detonate at random between the shortest and the longest delay times. The earliest time that a UXO may be activated, and the last time that it may detonate, are both limited between 3 minutes and 20 days, with the obvious proviso that the last time for detonation must at least equal the earliest time. A percentage of the UXO may be designated as delayed cratering munitions; the coordinates of these weapons will be passed to TSAR with other runway hit data, and will cause a crater to erupt after the designated delay time.

The UXOs delivered during one attack must be of no more than three types; if four or more types are delivered in a single attack the additional types are treated as the first type entered for that attack, and a warning message is printed in the TSARINA output. (This limitation could be overcome in certain circumstances by delivering UXOs of different types in closely spaced separate attacks.)

The organization of the data on this card are:

Columns	Data Entry
1–3	UXO
11–12	Number designating the weapon type.
13–18	Shortest delay time (TTU) after attack for a UXO to detonate.
19–24	Longest delay time (TTU) after attack for a UXO to detonate.
25–30	Percentage of the UXO removal team that are casualties.
31–36	Percentage of the removal team casualties that are killed.
37–42	Fraction of the equipment being used by the team working on a UXO that detonates that is lost.
43–48	Percentage of other teams on the same taxiway segment that are injured.
49–54	Fraction of the equipment in use by teams working on the same taxiway segment that is lost.

55–60	Percentage of the teams working on adjacent taxiway segments that are injured (<100).
61–66	The percentage of the weapons designated UXO that are to be treated as delayed cratering munitions in TSAR (default = 0).

PATT

The PATTern card provides four options for describing the locations of point-impact submunitions in a pattern. With this card, an ATT card (or an ATTK card) may be used to simulate one vehicle delivering one or more submunition dispensers, each of which opens to deliver point-impact submunitions. The first type of pattern is used to define an ordered pattern. The second and third pattern types distribute submunitions uniformily at random within a rectangle, or an ellipse, respectively; the fourth pattern type distributes submunitions such that their locations in range and in deflection are drawn from normal distributions. Up to ten different patterns may be defined. The location of the nominal impact points of all dispensers are offset from the intended impact location by downrange and crossrange distances based on a sample from the REP/DEP aiming data specified on the ATT (or ATTK) card; the location of the centroid of the individual dispensers is determined by the ballistic dispersion data on the ATT (or ATTK or ATTI) card. The impact location of each submunition in an ordered pattern is also affected by the ballistic dispersion data entered in columns 49–60 of this card. Weapon effects of each submunition are determined by the weapon type on the corresponding EMD data card. The weapon reliability entered on the EMD card is applied to the dispenser; if a TBM is simulated, missile reliability can be represented either with the arrival probability on the ATT or ATTK cards, or the weapon reliability on the EMD card, but *not both.* (For a TBM, the ATT card should specify one weapon, and a zero-length stick.)

For the first pattern type, a PATT card and up to 25 pairs of cards placed immediately after each PATT card define an ordered pattern of up to 400 submunitions. For the other pattern types, only the PATT card is required. The entries on the PATT card are:

Columns	**Data Entry**
1–4	PATT
6	Type of pattern.
7–12	The pattern number.
13–18	The number of submunitions in the pattern.

19–24	The weapon type that the pattern is to be associated with.
25–30	The reliability of each submunition times 1000; default = $1.0 \times 1000 =$ 1000.

For the Type #1 patterns, the standard deviations of the dispersion in range and deflection are entered in columns 49–60 of this card. Furthermore, the downrange and crossrange offsets for each submunition are entered with the card pairs that must immediately follow the PATT card. The first 16 downrange values are entered in five-column fields on the first card and the first 16 crossrange values on the second card; up to 25 card pairs are used to enter up to 400 submunition impact locations. Positive downrange values are measured ahead from the impact point of the dispenser along the attack heading; negative values are measured to the rear. Positive crossrange values are measured to the right of the attack heading and negative values to the left.

For the Type #2 and Type #3 patterns, the dimensions of the rectangular or elliptical patterns are specified on the PATT card as follows:

Columns	Data Entry
35–36	Blank
37–42	Downrange dimension of the rectangle or ellipse.
43–48	Crossrange dimension of the rectangle or ellipse.

For the Type #4 pattern, the entries on the PATT card are:

Columns	Data Entry
35–36	Blank
37–42	Standard deviation of the submunition pattern in range.
43–48	Crossrange standard deviation of the pattern.

A convenience that permits the user to quickly test different ordered pattern dimensions is activated when the number of a different ordered pattern (defined on a preceding PATT card) is entered in columns 35–36. When this is done a new ordered pattern is defined for which the downrange and crossrange dimensions are multiples of the reference pattern. The additional entries for the PATT card are:

Columns	Data Entry
35–36	A prior pattern number.
37–42	Downrange pattern dimension multiplier; specify 100 for 1.0.
43–48	Crossrange pattern dimension multiplier (if not entered the crossrange multiplier is set equal to the downrange multiplier).

When this feature is used, the downrange and crossrange offsets for the new ordered pattern will be (multiplier/100) times the size of those for the ordered pattern that is referenced in columns 35–36, e.g., 1.5 times longer and 2.0 wider if the multiplier entries are 150 and 200.

EQUI

The EQUIvalence cards are used to achieve consistency between the resources as defined in TSARINA and those defined in TSAR, when damage reports are prepared for transmission to TSAR. If the resources are defined identically in the data bases for both models, these cards are not required.

Resource equivalence data are entered using a specially formatted data string. The order of the data entered is: (1) the resource class, (2) the TSARINA resource type designator for which the equivalencies are defined, and (3) the TSAR designators of the resource types for which the percentage losses are to be equated to those of the designated TSARINA type. The numbers defining the resource classes are distinguished in the data string by addition of the number 20000.

If several TSAR resources are to be assigned the same TSARINA damage percentage, each of their numbers should immediately follow the number for the equivalent TSARINA resource. If necessary, the designator list can be continued on a subsequent card image when the 11 data fields are full; the list is terminated either by a null entry or by another resource class designator. However, the equivalence card cannot be used to equate a TSARINA resource designation to a Type #0 resource to signify "all types not otherwise specified" for TSAR; to take advantage of that option, the TSARINA resource designation should itself be #0. If the first entry following the TSARINA designator is –1, the TSARINA damage estimate for that resource is not reported to TSAR.

```
EQUI 20003  5  1  3  5  7  20003  6  2  4  6
EQUI        10  12  0
```

In this example, the first, third, fifth, and seventh types of aircraft spare parts, as defined for TSAR, are to be assigned the damage level assessed for the fifth type of spare part in TSARINA; similarly, the second, fourth, sixth, tenth, and twelfth TSAR spare parts are assigned the damage level assessed for the sixth type of spare part in TSARINA.

```
EQUI  20001  7  -1
```

In this case, estimates of casualties suffered by Type #7 personnel are not to be reported to TSAR, but only reported in the TSARINA output.

Another option is available when one wishes to specify that the damage level for a specific equipment or for a specific spare part in TSARINA is to be applied to all members of a consecutively numbered sequence of equipment types or spare part numbers in TSAR. Thus, for example, if one had used the part #21 to represent the locations of jet engine spare parts in TSARINA, and wanted that damage level to be applied to all parts numbered from 327 through 343, inclusive in TSAR, one could specify:

EQUI 20003 21 327 10026

The "10000" is a flag denoting that the damage level for TSARINA part #21 should be applied to TSAR part #327 and the next 26 consecutively numbered TSAR parts. This feature is only operative for equipment and spare parts.

A final complication is introduced for differentiating between on-duty and off-duty personnel, and between assembled and unassembled munitions. TSAR personnel designators with values less than 1000 refer to on-duty personnel; off-duty personnel are specified by adding 1000 to their normal designator. Note that types 0 and 1000 refer, respectively, to all on-duty and all off-duty personnel not otherwise specified. Complete sets of unassembled munition components are designated by adding the value NOMUN to the nominal munition designation; where NOMUN is the length of the munitions storage array MUNSTK in TSAR and is specified at the beginning of the TSARINA MAIN routine in the source code.

MCL

The MCL card permits the runways to be checked not only for the minimum number of repairs that would be required to clear an area equal to the nominal MCL × MCW (see CONT card) but also for the number of repairs required for up to three shorter lengths.

The clear-surface-area requirement is usually stated as that needed for full combat operations, with a normal load of weapons, for both launching and recovery. Under some circumstances, the (typically) lessor requirement for launching a combat sortie, or for simply evacuating a lightly loaded aircraft, would also be of interest.

When this feature is used the computation proceeds as before, searching all flight surfaces for that location with the least number of crater repairs required to clear an area of MCL by MCW; when that location is found, additional checks are made to see what portion of those repairs are required to clear any shorter lengths that the user has specified. In effect, it is assumed that the base engineers conduct the clearance operation at that location that will provide the basic MCL with the minimum repairs, but that they will organize their work such that any shorter lengths that have been specified will be given priority within the overall task. A check is also made to see whether or not one or more of these shorter lengths is available anywhere on base without any repair. When that situation exists no delay need be incurred for repairs.

Columns	Data Entry
1–3	MCL
7–12	Longest secondary length.
13–18	Next secondary length.
19–24	Shortest secondary length.

These additional lengths must be entered in decreasing size, and all must be less than the MCL entered on the CONT card. The width required for these shorter areas is assumed to be MCW.

The results for these additional computations are printed for each trial. In addition, statistics are provided for the fraction of trials in which these lesser lengths were available and for the average number of repairs when they were not. These data are *not* transferred to TSAR.

SKEW

The SKEW card directs that TSARINA search for MOS locations that are skewed, as well as parallel, to the sides of the runways. For each location considered that is parallel to the runway side, the program will also consider locations (that have the same southwest corner) that are skewed relative to the runway. The user specifies the angular step size between locations and the maximum skew angle that will be considered; the angular step size is a multiple of 1/4°. If two locations have the same number of repairs required to clear an MOS, the location with the smaller skew angle is selected. This feature will not operate for runways narrower than 150 percent of the MCW.

Columns	Data Entry
1–4	SKEW
7–12	The step size between skewed locations, in multiples of 1/4°; e.g., a "3" would imply an angular step size of 3/4°.
13–18	The maximum skew angle that will be examined; degrees. The maximum value permitted is 25°.

A NOTE OF CAUTION

This feature was not included in the parent AIDA model, nor earlier versions of TSARINA, because of a concern that it would greatly extend processing time, and because it was doubted that a base commander would permit a skewed MOS for combat operations. Furthermore, it was doubted that the repairs required for an MOS would be greatly reduced with a skewed MOS. However, this feature was added because we realized that skewed MOS locations should not be ignored on especially wide runways, and we were interested in considering the option of paving the space between the main runway and parallel taxiway on typical NATO airbases. Although this feature has been exercised only to a limited extent to date, we have observed some reductions in repair requirements, and *very substantial* increases in the required processing time. In a test of a hypothetical 1000 × 10000-ft runway, even the search for a parallel MOS took an uncommon time on our main frame, but when we also checked for possible skewed locations (1/4° steps) the processing time increased by *over a hundredfold*; to over 40 seconds *per trial*! Considering that an accurate estimate of the average repair requirements typically requires 200 to 1000 trials, it is clear that this feature should be used with caution.

BAR

The BAR card permits the user to simulate the use of a "portable" arresting barrier that may be added to a runway after an attack. The length of runway surface required for aircraft landings may be significantly reduced by the use of such an arresting barrier. A typical barrier consists of a cable across the runway that catches a hook on the bottom of the aircraft and then unwinds from drums at the ends of the cable as the aircraft continues down the runway. The amount of cable that unwinds after the aircraft hooks up to the cable is controlled by braking mechanisms on the drums. For each runway that is a candidate for the addition of a barrier, TSARINA will find the "best" section of runway to be used with the barrier (there may be several best sections and only the first such found is presented in the output).

The arresting barrier requires a clear runway area of width MCW and length LABAR + LBBAR, where LABAR is the landing area ahead of the barrier and LBBAR is the landing area behind the barrier. In addition, the area swept over by the arresting cable must also be clear, i.e., the triangular-shaped areas contained between each drum and the side of the landing area behind the barrier must be free of obstructions. Each of these triangular areas has an area equal to (WDBAR – MCW) × LBBAR/4, where WDBAR is the barrier width.

The "best" runway area for the barrier is defined to be the one that minimizes a weighted sum of the numbers of the bomb craters in the landing area and the two triangular areas behind the barrier, i.e., minimizes RUNWT × HOLER + BARWT × HOLEB, where RUNWT and BARWT are the weights and HOLER and HOLEB are the number of craters in the landing area and the triangular areas, respectively. The two weights are included to reflect the fact that different resources are needed to clear the two different types of areas—the triangular areas need only be cleared of debris above the ground surface, whereas the landing area must be cleared of debris and any bomb craters in the landing area filled with runway repair materials.

Columns	Data Entry
1–3	BAR
12	The runway number.
13–18	The barrier width, WDBAR.
19–24	The length of the required landing area ahead of the barrier, LABAR.
25–30	The length of the required landing area behind the barrier, LBBAR.
31–36	Relative weight for craters in the landing area, RUNWT.
37–42	Relative weight for craters in the triangular area, BARWT.

The use of the barrier feature for a runway is exclusive of the multiple MCL feature for that runway, as described earlier in this section.

TEST

This special card provides the user the means of debugging a TSARINA run for a particular case(s), particular trial(s), and particular attack(s), rather than debugging all or nothing during a run. This card also permits the user to specify the initial seed for a one-case, one-trial run, thereby repeating a single case and trial; this feature is facilitated by listing the current random number at the beginning of each trial. These two features may be used separately or together. When no value is entered in columns 18, 30, or 42 for the first case, first trial, or first attack card, the default value is 1; when no value is entered for the number of cases, trials, or attack cards, the default value is 1000.

When the initial seed has been specified to be able to repeat a particular case and trial, the user must assure that the target cards and attack cards initially read are correct for the case and trial in question; it is then only necessary to specify one trial to repeat the trial from which the specified seed had been copied.

Columns	Data Entry
1–4	TEST
7–12	The value of KTEST to be used during particular cases, particular trials, and for particular ATT cards.
13–18	The number of the first case to be debugged.
19–24	The number of cases to be debugged.
25–30	The number of the first trial to be debugged.
31–36	The number of trials to be debugged.
37–42	The first attack card that will be debugged.
43–48	The number of attack cards that will be debugged.
49–60	The SEED will be initialized to this value (right-adjust).
61–66	If not zero, the status of each shelter is listed at the end of each trial.

REDO

The REDO card is used to terminate the input for one case and initiate a new case with some or all of the previous inputs, as described earlier.

Columns	Data Entry
1–4	REDO
7–12	All targets will be retained unless the entry is unity (1); in that case a new set of targets and a new set of attacks are required.
13–18	The number of prior attacks to be retained when the targets are not changed. Each attack is numbered in the order in which it is entered; the attacks retained are selected from the top of that ordered list. All will be retained if there is no entry. Use a negative entry (–1) if none are to be retained.
19–24	An entry of unity (1) suppresses the input listings for targets and/or for attacks and weapons if no changes have been made in these data sets from the prior case.
25–30	When a 1 is entered the subsequent attack will be considered as one of a sequence of attacks, and the percentage losses for POL in the subsequent attack will be computed on the basis of the damage to the POL tankage that survived prior attacks.
31–35	When a 1 is entered, the seed for the subsequent attack will be identical with the seed for the last attack in which a CONT card was entered, if a seed was defined with an entry in columns 8–9 of that card.

END

An END card must be included at the end of all data entry cards.

Columns	Data Entry
1–3	END

Appendix B

DEFINITIONS OF VARIABLES AND ARRAYS USED IN TSARINA COMMON STATEMENTS

KEY VARIABLES

ATTSEQ	When 1 implies the subsequent attack is to be considered one in a sequence; used when POL tankage is recorded.
ATTYPE	Type of attack: 1 = conventional; 2 = chemical; 3 = conventional and chemical.
BASE	The number of the airbase, in TSAR, at which the attack occurs.
CHANGE	Switch; set to unity between cases when the target data are to be changed.
CWHITS	Maximum number of individual chemical deposition patterns in an air attack.
DAY	The day, during the TSAR simulation, on which the air attack is presumed to occur.
DEGREE	Atmospheric temperature (°F).
HDGUNC	Uncertainty in attack planner's estimate of the wind direction.
HOUR	The hour, during the TSAR simulation, during which the air attack is presumed to occur.
IDNUM	An identification number selected for each TSARINA run.
INL	Distance along the runway the "minimum runway rectangle" is shifted.
INTSAR	Switch; set to unity when results are to be generated for TSAR.
INW	Lateral distance that the minimum runway rectangle is shifted in checking for an adequate section.
ISAVE	Switch; set to unity if resource damage results are to be generated for the auxiliary FORMATER program.
ITRIAL	Number of the current trial.
KCBU	Switch; set to unity if dispenser weapons or chemical weapons are used.
KPTI	Switch; set to unity if any weapons are the point-impact type.
KTEST	Index controlling debugging printout options.
LAST	Switch; set to unity for last case.

LIST	Switch; when set to unity, target and/or attack input lists are suppressed when unchanged.
MAXSHL	Maximum number of aircraft shelters at an airbase.
MCL	Minimum adequate length for required runway.
MCR	Switch; set to unity when runway availability is to be checked.
MCW	Minimum adequate width for required runway.
METCAT	Pasquill stability category (3 = C, 4 = D, 5 = E, or 6 = F).
MINE	Set to 1 when any of the weapons used in an attack delivers mines.
MINUTE	The minute, during the TSAR simulation, at which the air attack is presumed to occur.
MODE	Index controlling mode of operation.
MTRIAL	Array storage for POL tankage data is adequate for MTRIAL trials.
MTT	Largest target-type number in the target array.
MXCBU	Maximum number of CBU dispensers per attack.
MXHITS	Maximum number of hits that can be stored for each runway.
MXITEM	Maximum number of entries in the STOCKS array.
MXMOS	Maximum number of MOS hits that can be stored for one attack.
MXMP	Maximum number of chemical monitoring points.
MXPATT	The largest pattern number for type of patterns.
MXRWY	The maximum number of "flight surfaces"; i.e., Type #1 targets.
MXSKEW	The maximum angle considered when searching for a "skewed" MOS.
MXSUBS	Maximum number of submunitions in a controlled pattern.
MXTANK	Dimension of the POLTNK array.
MXTWX	Maximum number of taxiway arcs.
MXWPN	Maximum number of weapon types.
NA	Total number of weapon-delivery passes.
NAM	Maximum permissible number of weapon-delivery passes.
NBASE1 NBASE2	First and second part of base name.
ND	Number of types of weapons in overall attack.
NDUD	Number of weapon types used as UXO in a particular attack.
NHITD	Switch; set to unity when the expected-value mode is specified.
NJMEM	Number of weapon-delivery passes that require trajectory calculations.

NMCL	Number of lengths used for determining crater repair requirements.
NMP	Number of monitoring points.
NOAGE	Maximum number of entries in the AGE array; one greater than the size of the AGESTK array in TSAR.
NOEQUI	Maximum number of entries in the EQUIV array.
NOFAC	Maximum number of entries in the FACLTY array in TSAR.
NOMATL	Maximum number of entries in the MATERL array; one greater than the corresponding TSAR array.
NOMUN	Maximum number of entries in the AMMO array; 101 units greater than the MUNSTK array in TSAR.
NOPART	Maximum number of entries in the PARTS array; one greater than the corresponding TSAR array.
NOPEO	Dimension of PEOPLE array in TSARINA; equals (2 × NOPEOP + 2).
NOPEOP	Maximum number of entries in the PEOPLE array in TSAR.
NOPOL	Maximum number of entries in the POL array.
NOTRAP	Maximum number of entries in the TRAP array; one greater than the corresponding TSAR array.
NPLOT	Switch; set to 1 or 2 if runway impact plots are desired.
NPRINT	Index controlling results that are to be output.
NREDO	Switch; set to unity if an additional case is specified.
NREP	Switch; set to unity when repair requirements are to be assessed.
NSAVE	The number of weapons-delivery passes saved from one case to be used in the next case.
NSM	Total number of aircraft shelters.
NST	Maximum number of targets for which hits can be stored.
NSQDA	Number of aircraft shelters used for alert aircraft.
NT	Total number of targets entered using the TGT cards.
NTM	Maximum permissible number of targets.
NTRIAL	Total number of trials specified.
NUMHIT	Total number of targets affected by any weapon radii of any weapon.
PATM	Atmospheric pressure (Torrs).
PDAM	Switch; position controls output formats for trial-to-trial damage summaries.
RAMPS	Target-type chosen to designate aircraft parking aprons and ramps.

ROTATE	The angular step size for checking repairs on skewed MOS locations (multiples of 0.25°).
SAVHIT	When = 1, the coordinates of all impact points are stored on device "12" for subsequent use.
SHELT1	Target-type chosen to designate Type #1 aircraft shelters.
SHELT2	Target-type chosen to designate Type #2 aircraft shelters.
SHELT3	Target-type chosen to designate Type #3 aircraft shelters.
TAXI	Minimum clear width needed for an aircraft to safely transit a damaged taxiway.
TOTMAE	Total mean area of effectiveness against "aircraft in the open" for all weapons in the attack.
TOTPOL	Total POL storage specified.
TRKFIL	Target-type chosen to designate fuel truck refilling locations.
TSAR	When greater than zero, output for TSAR is stored on disk.
TTRIAL	Maximum number of trials for which unnecessary taxiway casualty data are not passed to TSAR.
TXWYS	Target-type chosen to designate taxiways.
VEL	Wind velocity for the trial.
VELUNC	Percentage uncertainty in the attack planner's estimate of the wind velocity.
VDELAY	When = 1, the postattack delays CEDELY and SHPDLY in TSAR will be a function of the weight and extent of the attack.
WIND	Wind direction for the trial.
WINDIR	Estimated compass direction of the wind (deg).
WINVEL	Estimated wind velocity (m/s).
WXTYPE	Number identifying the meteorological conditions to be assessed by TSAR at the time of the attack.
XMM YMM	Distance targets, attacks, and monitoring points are translated in the x and y directions to place all targets in the first quadrant.

KEY ARRAYS

All arrays listed in the labeled Common in TSARINA are defined below. The first seven arrays store data pertaining to AGE and equipment, munitions, building materials, aircraft spare parts, personnel, POL, and TRAP, respectively. The definitions shown below the array names are the same for all of these arrays.

AGE(I,J)
AMMO(I,J)
MATERL(I,J)
PARTS(I,J)
PEOPLE(I,J)
POL(I,J)
TRAP(I,J)

I =	Type of resource.
J = 1	Pointer to the location in the STOCKS array, where the first quantity of this resource is stored.
2	Cumulative losses at all targets where this resource is stored.
3	Square of the cumulative losses.
4	Pointer to the location in the EQUIV array, where the first equivalent TSAR resource category designations are stored.

For personnel J = 5 – 7 is the weighted average chemical deposition by agents (J – 4) in the areas where the personnel are located.

AGENT(I,J)

J = 1	Transport velocity of agent I from liquid surface films on grass to the internal portion of the grass (cm/min).
2	Number of agent I.

AIMPNT (I,J)

I =	Number of an IAM; numbered internally for each IAM used in an attack.
J = 1,2	X and Y coordinates of the aim point for the I*th* inertially aided munition.

ATT(I,J) Storage array for weapon-delivery data.

I =	Weapon-delivery pass number; numbered internally in order of entry.
J = 1	Heading (deg).
2	X-coordinate of desired mean point of impact.
3	Y-coordinate of desired mean point of impact.
4	REP of DMPI.
5	DEP of DMPI.
6	Dispersion in range (ground plane).
7	Number of weapons released in pass.
8	Length of stick (in ground plane).
9	Weapon type.
10	Dispersion in deflection.
11	Probability attacker arrives at target.
12	Chemical dispenser burst altitude (ft/10).
13	Attack heading uncertainty, degrees.
14	Inclination angle at impact; degrees off vertical.
15	Percentage of the passes directed at the alternate aim point (see AIMPT (–,2)).
16	X-coordinate of the alternate aim point.
17	Y-coordinate of the alternate aim point.
18	Dispersion in range for AIMPT(–,2).
19	Dispersion in deflection for AIMPT(–,2).

ATTPT(I,J)

I =	Weapon delivery pass number; numbered internally in order of entry.
J = 1	Target designator of the intended aim point; 1 to 6 alphanumeric characters.
= 2	Target designator of an alternate "unintended" aim point (see ATT(–,15) for application).

BARWT(I) Weight given to holes off the runway, but in the triangular area swept by the mobile barrier cable, on runway I.

CBUHT(J,K)	Impact coordinates of the centroid of the *Jth* CBU pattern.
K = 1	X-coordinate.
2	Y-coordinate.
CKUXO(I)	Initialized to 1 when data are entered for weapon type I UXO.
CKWPN(I,6)	Used to check adequacy of input data for weapon type I, et al.
COV(L)	Fraction of target L covered by one or more CBU patterns.
COV2(I,J)	
J = 1	Expected number of weapons that impact within R1 feet of aircraft shelter "I".
2	Expected number of weapons that impact within R2 feet of aircraft shelter "I".
CWPATT(I,L)	
I =	Number of the pattern in the attack.
L = 1(2)7	X-coordinate of pattern corners.
= 2(2)8	Y-coordinate of pattern corners.
= 9	For rectangular pattern, is 1 if pattern is aligned with coordinate axis; 0 otherwise. For spray pattern, is 1 if wind is aligned with a coordinate axis; 0 otherwise.
= 10	For spray pattern, is 1 if delivery heading is aligned with a coordinate axis; 0 otherwise.
DODUD(I,J)	
J = 1	Fraction of the type I conventional weapons that do not explode on contact; special control for CW weapons.
J = 2	Distance from taxiway to which unexploded type I conventional weapons must be rendered safe.
= 3	Minimum time delay for type I UXO detonation (TTU).
= 4	Maximum time delay for UXO detonation (TTU).
= 5	Percentage of the UXO removal team that are casualties.
= 6	Percentage of the removal team casualties that are killed.
= 7	Fraction of the equipment used by the removal team that is lost.
= 8	Percent of other teams working on the same taxiway segment that are casualties.

= 9	Fraction of the equipment used by other teams on the same taxiway segment that is lost.
= 10	Percent of teams working in adjacent taxiway segments that are casualties.
= 11	Fraction of the UXOs that are buried and create a delayed crater when they burst.
DOSE(I,J)	Surface contamination of agent J on target I.
DUDS(I,J)	Number of unexploded weapons of type TYPDUD(J) on target I.
DUPTGT(I)	Stores the record for I duplicate targets.
EMD(I,J,K)	Weapon effectiveness data.
I =	Weapon type.
J	Target type.
K = 1	Effective miss distance R1 for a near miss.
2	Effective damage radius R2 for a near miss.
3	Personnel damage factor for a near miss.
4	Equipment damage factor for a near miss.
5	Aircraft spare parts damage factor for a near miss.
6	Munitions spare parts damage factor for a near miss.
7	TRAP damage factor for a near miss.
8	Building material damage factor for a near miss.
9	Coded flag defining the criteria for assessing resource damage.
10	Effective miss distance R1 for a direct hit.
11	Effective damage radius R2 for a direct hit.
12	Personnel damage factor for a direct hit.
13	Equipment damage factor for a direct hit.
14	Aircraft spare parts damage factor for a direct hit.
15	Munitions damage factor for a direct hit.
16	TRAP damage factor for a direct hit.
17	Building material damage factor for a direct hit.
EQUIV(NOEQUI)	Used to store the resource designators to be used for reporting damage to TSAR.

FACLTY(I)	Used to store the TSAR facility number for structures whose damage is to be reported to TSAR.
HGT(I)	Vertical dimension of target type I.
HIT(I,J,K)	Storage array for hit locations on specified targets.
I	I*th* of those targets for which hit data are to be stored.
J = 1	X-coordinate.
2	Y-coordinate.
3	Weapon type.
K	Number of hits on the I*th* target.
HITR(I,J,K)	Storage array for hit locations on Type #1 targets (i.e., runways and taxiways).
I,J,K	See HIT(I,J,K).
IR(N)	Switch; set to unity if the N*th* weapon-delivery attacker fails to reach target.
IZ(I)	Designates the zone for each target (see subroutine TGTZON).
IZONE(K,J)	Denotes which of the ordered targets fall in the K*th* target zone.
J = 1	Lowest numbered target in the K*th* zone.
2	Highest numbered target in the K*th* zone.
LABAR(I) LBBAR(I)	Length of the required area ahead (LABAR) and behind (LBBAR) the mobile barrier on runway I.
MHIT(K)	Target number of the K*th* target for which hit location data are to be stored.
MINES(I)	Number of mines that landed on or within the radiis of effectiveness of taxiway I.
MOSX(I)	X-coordinate of I*th* runway crater with an attack directed at the MOS determined subsequent to the prior attack.
MOSY(I)	Y-coordinate of the I*th* runway data.
MOSR(I)	Radius of the I*th* runway crater.

MPDOSE(MP,I,J)

J = 1	Surface deposition of agent I at monitoring point MP.
2	Steady-state vapor concentration of agent I at monitoring point MP.
MSTAT(J)	Storage array for accumulating trial results of runway availability tests.
J = 1	Minimum number of repairs required to open a minimum runway.
2	Square of J = 1, above.
3	Minimum repairs for longest secondary clear length.
4	Square of J = 3.
5	Minimum repairs for next secondary clear length.
6	Square of J = 4.
7	Minimum repairs for shortest secondary clear length.
8	Square of J = 5.
MTYPE(I)	Index that specifies whether or not supplementary data are to follow the EMD card for weapon type I.
NAME(I,2)	Stores either a two-word or alphanumeric name for each target.
NCASE(I)	Number of cases for base I.
NCBU(L)	Number of CBU weapon patterns that cover all or part of target L.
NHIT(L)	Number of hits on target L; by both point-impact and CBU weapons.
NRW(I)	Target number of the I*th* runway entered.
NSTAT(I)	Cumulative number of trials in which the I*th* runway clear length was available without crater repair.
NTEST(I)	Used locally in subroutine RUNWAY.
NZ(I)	When "1" identifies hit I as a CBU pattern.
OHIT(I)	Counts near misses for each target.
P(L,K)	Damage estimates for target L.
K = 1	Expected fraction of target L that is within the radius R1 of point-impact weapons.

2	Expected fraction of target L that is within the radius R2 of point-impact weapons.
3	Fraction of personnel casualties expected at target L.
4	Fraction of equipment losses expected at target L.
5	Fraction of spare parts losses expected at target L.
6	Fraction of munitions (or POL) losses expected at target L.
7	Fraction of TRAP losses expected at target L.
8	Fraction of building material losses expected at target L.
P2(L,K)	Damage estimates for aircraft shelters.
K = 1	Expected fraction of aircraft shelter L within radius R1 of the weapon impacts.
2	Expected fraction of shelter L within radius R2 of the weapon impacts.
3	Probability that a sheltered aircraft is damaged when the shelter door is closed.
4	Probability that a sheltered aircraft is killed, when the shelter door is closed.
5	Probability that a sheltered aircraft is damaged, when the shelter door is open.
6	Probability that a sheltered aircraft is killed, when the shelter door is open.
7	Probability that the shelter is killed.
8	Expected damage to the shelter.
PADS(I)	Target type of I*th* type PAD.
PADLTH(I)	Pad dimension measured out from the aircraft shelter door for PAD type I.
PADWID(I)	Width of type I PAD.
POLTNK(I,J)	Records loss of POL storage tank I during trial J.
QSTAT(I)	
I = 1	Sum of the expected damage to aircraft in alert shelters.
= 2	Sum of the square of the expected aircraft damage.
= 3	Sum of the expected damage to alert shelters.

= 4	Sum of the square of the alert shelter damage.
= 5	Sum of the percentage of aircraft damaged on ramps.
= 6	Sum of the percentage of aircraft destroyed on ramps.
= 7	Sum of the percentage of aircraft damaged on taxiways.
= 8	Sum of the percentage of aircraft destroyed on taxiways.
REPAIR(I)	The minimum number of crater repairs required to clear the minimum area for flight operations on runway I.
REPT(I)	Set to 1 when target I is a taxiway or ramp and sustained damage or chemical contamination.
RUNWT(I)	Weight given to holes on runway I in selecting the MOS, when a mobile arresting barrier is used.
RWYREP(I,J)	For I = 1,5; number of trials in which J – 1 craters repairs were required to open an MOS on runway I. For I = 6; number of trials in which J – 1 was least number of crater repairs needed on all runways.
SHEL(I)	Target number of shelter I.
STAT(L,J)	Storage array for accumulating trial results.
L = 1	Number of hits by point-impact weapons.
2	Square of J = 1, above.
3	Trials with at least one hit.
4	Fractional coverage by CBU weapons.
5	Square of J = 4, above.
6	Fractional target coverage within radius R1 of point-impact weapons.
7	Fractional target coverage within radius R2 of point-impact weapons.
8	Fractional personnel casualties.
9	Fractional equipment losses.
10	Fractional spare parts losses.
11	Fractional munitions losses.
12	Fractional TRAP losses.
13	Fractional building material losses.

STATUS(I)	Status of aircraft shelter I: 2 = shelter and contents destroyed; 3 = sheltered aircraft is damaged; 4 = sheltered aircraft is damaged if door is open.
STOCKS(I,J)	Resource storage location information.
J = 1	Target number at which resource is located.
2	The percentage of the resource stored in this location (in tenths of percent).
3	Pointer to next target with the same type of resource.
SUBMUN(I,J)	
J = 1	Pattern number associated with weapon I.
2	Number submunitions in pattern.
3	Submunitions reliability.
TGT(L,J)	Storage array for target data.
L	Target number; numbered internally in order of entry.
J = 1	X-coordinate of westernmost corner (#1).
2	Y-coordinate of corner #1.
3	X-coordinate of corner #2.
4	Y-coordinate of corner #2.
5	X-coordinate of corner #3.
6	Y-coordinate of corner #3.
7	X-coordinate of corner #4.
8	Y-coordinate of corner #4.
9	Heading of northeast target leg.
10	Target type.
11	Switch; hits stored when set to unity.
12	Dimension of northeast target leg.
13	Dimension of southeast target leg.
14	Facility number of target.
15	X-coordinate of target center.
16	Y-coordinate of target center.
TO(I,J)	Target order array in which targets are ordered according to increasing values of the sum of the coordinates of the western corner.

I	I*th* target in the ordered array.
J = 1	Value of (X + Y) for the I*th* ordered target.
2	Number of the target as initially entered.
TYPDUD(I)	Weapon type of up to three different weapons to create UXO in a particular attack.
WDBAR(I)	Width of the mobile barrier on runway I.
WPNDTA(I)	The weapon type that is joined to weapon type I to form a "compound" weapon.
WPNMAE(I)	Mean area of effectiveness of weapon type I against "aircraft in the open."
WPNREL(I)	Reliability of weapon type I.
XCOORD(I,J)	The downrange coordinate of the I*th* submunitions in pattern J.
XMP(I)	X-coordinate of monitoring point I.
YCOORD(I,J)	The crossrange coordinate of the I*th* submunition in pattern J.
YMP(I)	Y-coordinate of monitoring point I.

Appendix C

ORDER—AN AUXILIARY PROGRAM FOR PREPARING TSARINA "HIT" DATA FOR TSAR

ORDER uses as input the TSARINA hit data output for multiple bases, attacks, and trials. It rearranges the hit data and outputs all of it into a single FORTRAN direct access file consisting of 400-byte physical records. All variables are integer*2 and each output record is written by an unformatted direct access "write" containing 200 variables. The output records can be read into an array of 200 integer*2 variables by either an unformatted direct access read or by a formatted read with a format of 200A2.

ORDER is currently dimensioned to handle maxima of 20 trials and (for each trial) 10 bases, 5 runways per base, 10 attacks per base, 5000 total hits per runway, and 5000 chemical hit/MP entries.

ORDER requires that the runway and chemical hit data for all attacks for a given base and trial be in a separate input file. (Such files are most easily created by making separate TSARINA runs for each base containing all of the attacks on the base.) Input files for different bases but the same trial must have the same FORTRAN dataset reference number but different dataset sequence numbers as, for example,

```
FT41F001 DD DSN=TRIAL1.BASE1     FT42F001 DD DSN=TRIAL2.BASE1
FT41F002 DD DSN=TRIAL1.BASE2     FT42F002 DD DSN=TRIAL2.BASE2
FT41F003 DD DSN=TRIAL1.BASE3     FT42F003 DD DSN=TRIAL2.BASE3
```

where Trial #1 is FORTRAN dataset FT41, Trial #2 is FORTRAN dataset FT42, etc., and the FORTRAN dataset sequence number, e.g., F002, for a given base must be the same for all trials.

One input card is required for each base, in the same order as the bases are in the (input) datasets. The input cards have three fields (3I10) containing the base number, the number of trials, and an indicator variable. The indicator variable is set to one for the first base and to zero for subsequent bases—after the initial run of ORDER the output file may be updated for the last-numbered bases by omitting the FORTRAN datasets and input cards for the first-numbered bases. ORDER takes the runway hits (craters) from all attacks for a given base, runway, and trial and orders them by their Y-coordinates (as needed by TSAR). The ordered hit data are then filed in the output direct access dataset as

1.	Runway No., No. of hits, Base No., Trial No.	(8 bytes)
2.	Attack #, X-coord, Y-coord, WR	(8 bytes)
3.	Repeat 2 for each hit	
4.	Repeat 1 to 3 for each runway	
5.	0,0,0,0 (End of data for runway hits)	(8 bytes)

Note that the hits from all attacks on a given runway for a given trial are output together and that the attack number for each hit is indicated. This is done so that TSAR, by reading from the direct access dataset, can determine at the time of each attack all of the hits up to and including the attack, without keeping a large hit dataset in memory (containing the hit data for all hits for all runways and all bases). After each attack, TSAR allocates repair resources to repair craters and open the runway. A record is kept over time of the base, runway, and input sequence number of all repaired hits so that repaired craters can be ignored.

A chemical "hit" is the agent surface deposition and vapor concentration from one "layer" of a deposition pattern at an MP. ORDER takes the chemical hits from all attacks for a given base and trial and orders them by monitoring point number. The ordered hit data are then filed in the output direct access dataset as

1.	–MP No., No. of hits, Base No., Trial No.	(8 bytes)
2.	Attack #, Agent No., Wind velocity, T1	(8 bytes)
3.	T2, T3, Surfcd, Conc.	(8 bytes)
4.	Repeat 2 to 3 for each chemical hit	
5.	Repeat 1 to 4 for each MP	
6.	0,0,0,0 (End of data for CW hits)	(8 bytes)

The runway and CW hit data for each base and trial combination start a new output record and extend through as many (400-byte) records as needed for the data. The hit data for the first base and first trial start in record number 4.

Record 1 contains an array of pointers indicating the first and last records of hit data for a given base and trial. The array is POINT(2,10,10) where POINT(1,Base#,Trial#) is the number of the first record for the given base and trial, and POINT(2,Base #,Trial #) is the last record for the base and trial.

Record 2 contains an array containing attack times for each base and each attack. The array is ATTACK(2,10,10), where ATTACK(1,Attack #, Base #) is the day of the attack, and ATTACK(2,Attack#,Base#) is 100 × hour of the attack + the minute of the attack.

Record 3 contains an array of runway data for the runways of each base. The array is RUNWAY(20,10) where

RUNWAY(1,Base #) = LTH(1)	(2 bytes)
RUNWAY(2,Base #) = WID(1)	(2 bytes)
RUNWAY(3,Base #) = LTH(2)	(2 bytes)
RUNWAY(4,Base #) = WID(2)	(2 bytes)
RUNWAY(5,Base #) = LTH(3)	(2 bytes)
RUNWAY(6,Base #) = WID(3)	(2 bytes)
RUNWAY(7,Base #) = LTH(4)	(2 bytes)
RUNWAY(8,Base #) = WID(4)	(2 bytes)
RUNWAY(9,Base #) = LTH(5)	(2 bytes)
RUNWAY(10,Base #) = WID(5)	(2 bytes)
RUNWAY(11,Base #) = INL	(2 bytes)
RUNWAY(12,Base #) = INW	(2 bytes)
RUNWAY(13,Base #) = MCL	(2 bytes)
RUNWAY(14,Base #) = MCW	(2 bytes)
RUNWAY(15,Base #) = WDBAR	(2 bytes)
RUNWAY(16,Base #) = LABAR	(2 bytes)
RUNWAY(17,Base #) = LBBAR	(2 bytes)
RUNWAY(18,Base #) = RUNWT	(2 bytes)
RUNWAY(19,Base #) = BARWT	(2 bytes)
RUNWAY(20,Base #) is not used	(2 bytes)

where LTH(I) and WID(I) are the length and width of the I*th* runway and the remaining variables are used in determining the MOS. See definitions for the CONT and BAR card entries in App. A.

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